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This research was performed under the Federal Highway Administration HP & R program, Project A-8-6 "Influence of Highways on Water Quality".

16. ABSTRACT

Research was undertaken at three highway construction projects in California to determine the influence on the water-quality environment. The projects were located on Interstate 5 in northern California at Dunsmuir, Route 395 in the high desert area north of Bishop, and on Interstate 5 in south Sacramento County. Each project involved contact with a live stream or river. Field data were assembled for the preconstruction and construction periods. In addition, the I-5 Dunsmuir and Route 395 Bishop projects included data collection for the postconstruction period.

The data show that the water-quality study performed by the districts as part of the environmental assessment process is adequate to describe potential impacts in qualitative terms. Most construction-related impacts were not forseen in the preconstruction environmental assessment. This report discusses each project study and conclusions.

17. KEY WORDS
Water quality, pollution, erosion, revegetation, aquatic biology, channel alteration, environmental assessment for transportation projects

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

August 1979

FHWA No. A-8-6
TL No. 657081

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

ANALYSIS OF SHORT- AND LONG-TERM EFFECTS ON WATER QUALITY FOR SELECTED HIGHWAY PROJECTS

Study made by . . . . Enviro-Chemical Branch

Under the Supervision of . . . Earl C. Shirley, P.E.

Principal Investigator . . . . Richard B. Howell, P.E.

Report Prepared by . . . . . . Don I. Nakao
Richard B. Howell, P.E.
Jeffrey L. Gidley, Biologist

Assisted by . . . . Gary R. Winters, Biologist
Douglas M. Parks, P.E.
Martin E. Nolan

Very truly yours,

Neal Andersen

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

Attachment

DN:db

ACKNOWLEDGEMENTS

Many individuals contributed to various parts of the project during the course of the study from 1972-1978. The concept of the study originated with Mr. John Skog, now retired, who was the first supervisor of the then Environmental Improvement Section. Mr. Earl Shirley, successor to Mr. Skog as Chief of the Enviro-Chemical Branch, provided much guidance to the study.

The research was performed under the direction of Richard B. Howell, Supervisor of the Water Quality Section. Individuals from the Section who assisted on the study included:

Eric Torguson	Project Engineer 1972-74 (Now with State Water Resources Control Board)
Richard Wasser	Project Engineer 1974-75 (Now with State Water Resources Control Board)
Mas Hatano	Project Engineer 1976
Richard Spring	Project Engineer 1977-78
Joe Halterman	(Now with State Energy Commission)
Joe Egan	(Now with District 11)
Don Nakao	TransLab, Water Quality Section
Martin Nolan	TransLab, Water Quality Section
Gary Winters	TransLab, Water Quality Section
Jeffrey Gidley	TransLab, Water Quality Section
Douglas Parks	TransLab, Water Quality Section

Philip Caruso	TransLab, Electrical Section
Patrick Monahan	(Former TransLab employee)

Others who provided assistance were:

Robert Carney	District 02 Materials Engineer
Frank Kosko	District 02 Materials Department
Charles Moss	District 02, Resident Engineer (retired)
Robert Skidmore	District 03 Environmental Branch Chief
Don Foster	District 03 (deceased)
Jim Krause	District 03 (now with Regional Water Quality Control Board)
Don Kramer	District 03 (now with State Water Resources Control Board)
Frank Gau	District 03, Resident Engineer
Robert Yeager	District 09 Materials Engineer
Jim Kemp	District 09 Materials Department
Lou Wadsworth	District 09 Materials Department
Mike Eagan	District 01 Design
Arlon Sauls	District 01 Construction
Jim Ross	District 04 Environmental Branch
Roy Chalmers	Headquarters Design (Hydraulics)
Charles Jackson	Headquarters Construction
Dr. Andrew Leiser	Professor, Environmental Horticulture, U.C. Davis

Coordination with studies in other states during the course of this study and offering comments from the Federal Highway Administration were: Wayne Branch and Robert Cady of the California Division Office; Herbert Gregory of Region IX; and Byron Lord of the Washington Office.

Drafting of the figures was accomplished by Elmer Wigginton and the report was typed by Carol Johnson and Darla Bailey.

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic yards (yd^3)	3.785 .02832 .7646	litres (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour(mph) feet per second(fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity(G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^2)
Force	pounds (lbs) kips (1000 lbs)	4.448 4.448	newtons(N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb) foot-kips (ft-k)	1.356 1.356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs) foot-pounds(ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{\text{metre}}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{\text{metre}}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

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CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were derived from this study:

1. The water-quality studies, as part of the project environmental document, adequately described the potential long-term impacts in qualitative terms for the I-5 project north of Dunsmuir (District 02), the I-5 project located in south Sacramento County (District 03), and the Route 395 projects located north of Bishop (District 09). The studies were carried out according to prescribed procedures. Project monitoring by the Transportation Laboratory (TransLab) confirmed the projected impact assessments.

2. The use of instream macroinvertebrate monitoring appears to be successful in determining the extent of impacts, if any. In the case of Rock Creek, it successfully showed no impacts even though a moderate slope erosion problem occurred at Upper Sherwin Grade.

3. Water-quality-related data were successfully obtained by each District. This was attributed largely to the TransLab training courses in procedures for conducting studies and laboratory testing.

4. Each District has Approved Water Testing Laboratories as designated by the California Department of Health Services. This added validity to the test results reported for each study.

5. All short-term impacts associated with the highway construction were not foreseen in the District's preconstruction water-quality studies. Almost all short-term construction impacts involved erosion and subsequent sediment transport into a stream. District Materials and Physical Environmental Studies personnel were involved in recommending mitigation measures to cope with the short-term impacts that arose. TransLab research personnel participated with the Districts in prescribing the treatments. In all cases, the short-term impacts were successfully mitigated.

6. Mitigation measures were effectively used on all three projects. The revegetation of the large cut slope on the I-5 job at Dunsmuir resulted from utilization of information on plant material for the TransLab research project at Lake Tahoe with the University of California, Davis.

The use of fiberglass roving in various roadway ditches at I-5 Dunsmuir and on the upper slope area of the embankment near Rock Creek at Upper Sherwin Grade on Route 395, resulted from TransLab studies with fiberglass roving. These installations were successful in reducing ditch scour and slope erosion.

The embankment slope at Upper Sherwin Grade on Route 395 experienced severe rill and gully erosion during the winters of 1977-78. Short willow wattling bundles, to serve as check dams within sections of each gully, were recommended by TransLab and installed by District 09 using California Conservation Corps personnel in the spring of 1979 to reduce the gully erosion.

Willow wattling was also installed as part of the contract on the I-5 Dunsmuir project. The wattling on the Dunsmuir project was successful in reducing slope erosion. However, the live plant material died during the summer period following its installation. It is suspected that the reason was because it was installed during the early part of the summer when the slope was dry and also because approximately half of it was cut at a site near Redding and trucked to the job site which was some 40 miles away. It is possible the willow dried out during transit.

TransLab and District 02 installed three experimental willow wattling bundles on the slope after construction was completed. These bundles have excellent growth two years after their installation. This indicates that the willow wattling and cuttings will grow on the slope if properly planted.

7. The testing of soil for nutrients with a soil test kit for the Sherwin Grade project in District 09 revealed useful information as to the requirements for fertilizer specifications.

The following recommendations are made:

1. Most of the required background water-quality information can be obtained from data banks such as STORET maintained by EPA, and WATSTORE and NAWDEX maintained by the U.S. Geological Survey.

2. Analysis of data in quantitative terms is lacking in several instances. Procedures for analyzing water-quality data in quantitative terms need to be developed to assist

District environmental staff in assessing potential environmental impacts. This information will also be useful in designing appropriate mitigation measures. Only projects that have a direct bearing on a stream, lake, wetland, or other aquatic feature, need have a comprehensive water-quality study performed. The quantitative analysis of data should be limited to these cases.

3. Districts should continue to have personnel involved in water quality studies attend in-house training courses, such as those sponsored by TransLab and other short courses provided by others.

4. Methods for evaluating a project for short-term erosion and sediment impacts need to be prepared to assist the districts in their assessments. Additional studies that focus on construction-related impacts need to be undertaken in order to develop adequate procedures to evaluate projects.

5. Guidelines for placement and design of temporary sediment-settling basins need to be prepared.

6. Water-quality inspection during construction for projects that involve a water resource needs to be strengthened. Several instream sediment impacts occurred that were not known to construction personnel until pointed out by the research staff. Use of periodic water-quality inspections by district environmental or materials department staff who are trained in water quality may be useful in strengthening this area.

7. Construction inspectors assigned to erosion control of water quality should receive appropriate training.

8. The Districts should implement a procedure for conducting follow-up inspection of completed projects for water-quality factors. The inspection should be carried out by staff members trained in water quality. For more environmentally sensitive areas, TransLab water-quality staff may be used in the evaluation. For example, follow-up work is being conducted on the Route 395 project at Upper Sherwin Grade to reduce the potential erosion problem on the embankment slope above Rock Creek.

9. Instream macroinvertebrate monitoring should be used by trained TransLab biologists on more projects during construction and postconstruction periods to provide useful information on whether stream impacts occur or not and if any follow-up mitigation is needed.

10. Contacts between TransLab researchers and district environmental, materials, and construction personnel, should continue on other projects for implementation of research findings.

11. Contract special provisions should delineate a time for seeding or transplanting plant material that is most conducive to the successful germination or establishment of the vegetation. In general, seeding or planting should not be allowed during the dry summer months.

12. TransLab and the Offices of Construction and Landscape Architecture should perform additional studies for incorporating testing of soil nutrients on future projects to develop fertilizer specifications for vegetation.

13. Coordination with other agencies is successful in alleviating "fears" of potential impacts and explaining mitigation that will be used to reduce adverse impacts. These contacts should continue and perhaps be expanded on a more informal basis. Informal contacts with other agencies were successfully made on the three projects studied. It is recommended that the districts continue this practice. Among the various agencies that should be involved are: Regional Water Quality Control Boards, Department of Fish and Game, Resource Conservation Districts, U.S. Soil Conservation Service, and the U.S. Forest Service.

Memorandums of understanding may be established in some instances to enhance the usage of technical assistance to evaluate impacts and plan mitigation measures. This is in concert with Caltrans Best Management Practices for Control of Water Pollution (Transportation Activities), Sec. 208 of Public Law 92-500(41).

14. There is a need for research to be completed similar to this study for construction projects located along the California coastal zone (north, central, and southern), in the Los Angeles-San Bernardino area, in the Fresno-Bakersfield area, and in the Sierra Nevada mountain region.

15. There is a need for research to develop alternative water-quality studies for small-scale projects that only require a Negative Declaration as opposed to comprehensive studies for projects requiring an Environmental Impact Statement.

IMPLEMENTATION

Copies of this report will be provided to each of the eleven transportation districts and Headquarters Offices. Copies will also be given to other interested persons. The Federal Highway Administration (FHWA) will handle distribution of the report within FHWA and to other state highway agencies.

The District Project Development Teams can utilize information in this report in considering water-quality aspects for the environmental clearance process. Utilization of TransLab water-quality specialists and biologists by the districts can enhance the application of the information in this report. Review by TransLab of district technical water-quality studies will continue to insure adequate consideration of environmental factors.

The Office of Transportation Laboratory, Water Quality Section, will continue to arrange for formal training courses to assist districts and Headquarters staff in analyzing project impacts on water quality, erosion control, solid waste, and appropriate mitigation methods. Special seminars can also be presented to functional groups to meet specific needs in the above areas. Appropriate water-quality manuals and guidelines, based in part on experience gained in this research, will be issued as needed to meet the ongoing needs of the Department.

Research will continue in various areas to improve the environmental impact assessment method and develop practical guidelines for routine water-quality studies. Research on development of cost-effective mitigation measures to further protect the water-quality environment will continue.

Coordination with other agencies concerning water-quality matters will continue on a formal and informal basis.

INTRODUCTION

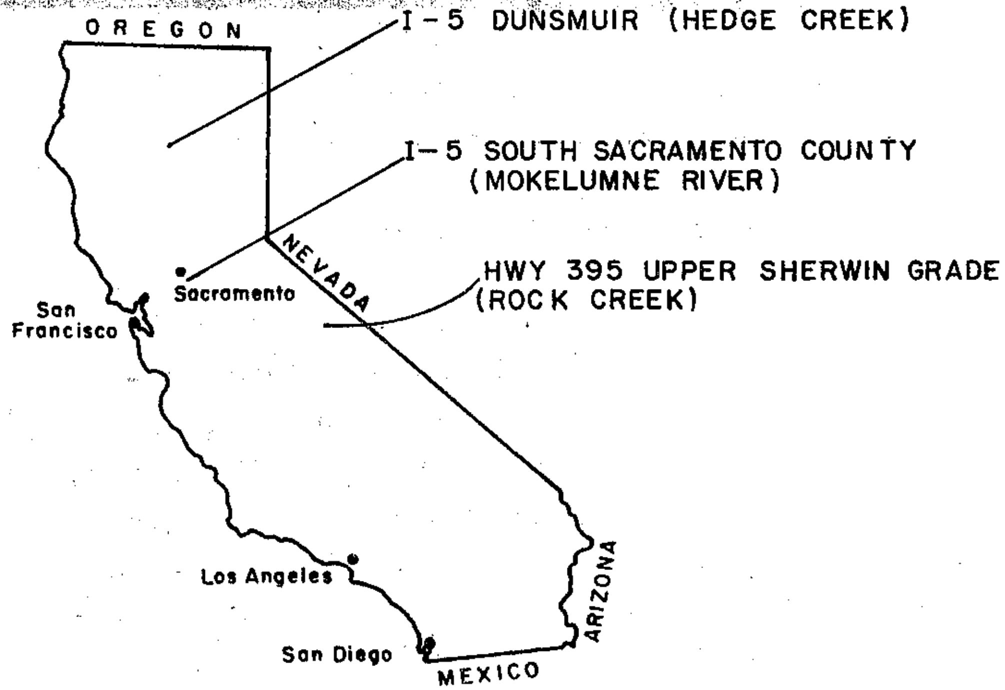
The purpose of this research was to: 1) evaluate the influence of highways on water quality, 2) determine temporary- and long-term impacts (if any), and 3) evaluate the adequacy of the water-quality study conducted as part of the environmental investigation. Three projects were studied during this research:

1. I-5 north of Dunsmuir (Hedge Creek)
2. Rte 395 north of Bishop (Rock Creek)
3. I-5 south of Sacramento (Mokelumne River)

The location of these projects is shown in Figure 1.

The study, as originally proposed, was to establish water-quality monitoring on five to six upcoming construction projects and then continue monitoring through the construction period and for about one year following construction. This information would provide data that could be used to determine if the preconstruction water-quality study was adequate, to determine any impacts that occurred that were not anticipated during the course of the study, and to determine if impacts were properly mitigated as proposed.

A set of criteria was established which was used in the selection of projects to study. Only those upcoming construction projects that were scheduled to begin construction within 1-3 years were considered. Also, the projects had to have a nearby water course within the limits of construction, and preferably involve a channel change, bridge, or have a nearby body of water that received drainage from the project.



LOCATION MAP

FIGURE 1

These criteria narrowed the number of potential projects considerably. They also focused major attention on those areas of California which include fishing streams or rivers that migratory fish utilize such as are found along the north coast.

A number of upcoming projects were identified and field studies initiated. However, funding problems began with the highway construction program in 1973 and continued in subsequent years. District construction schedules were vastly altered. Every project that had been selected for study was either deleted from the construction program, moved into future years, downscoped in size, or altered to the degree that none of the originally anticipated water-quality effects would occur. The following is a table showing the projects initially selected and their disposition.

Table 1 Summary of Initial Study Projects

Project	Date Study Started	Date Study Stopped	Status
03-ED-49 (Coloma)	Feb. 72	Oct. 72	Project deleted
03-Nev-20 (Rex Res.)	Nov. 72	June 73	Project deleted
04-Ala-I-580 (Dublin)	Jan. 73	June 73	Project rescheduled
01-DN-199 (Smith R.)	July 73	Oct. 73	Project downscoped
03-ED-50 (American R.)	Oct. 73	May 74	Project downscoped
01-Men-101 (Russian R.)	Aug. 74	May 75	Project rescheduled

Because of the problems in trying to find a future construction project that could be monitored for 1-3 years prior to construction, FHWA and Caltrans agreed to begin monitoring a project that was just getting underway and use the district's water-quality study data developed for the environmental document as the baseline (preconstruction condition).

The eleven Caltrans Transportation Districts were surveyed by letter in 1975 requesting assistance in locating a construction project that was just starting and that involved a water course of some type. Only three projects that met these stipulations were identified by the districts. One of these three was deleted because the estimated construction date was about one year away and that was contingent on getting environmental clearance.

Of the remaining two projects, one was located in District 02 on I-5 north of Dunsmuir. The project involved relocating approximately 500 feet of Hedge Creek and constructing a large cut which was a potential erosion problem. After a review of the project, it was selected for field study which got underway in July 1975. Unfortunately, during the following two years, California experienced a severe drought. The 1976-77 winter was the driest year of 130 years of record in California and was the second consecutive year of the worst two-year drought in California's history. The low runoff adversely affected field measurements for the I-5 project.

The other project involved a series of three construction jobs on Route 395 north of Bishop (Sherwin Grade). Rock Creek flowed under the highway at the upper and lower ends of the construction limits. A small channel change was involved and the Lahontan Regional Water Quality Control Board required close monitoring by District 09. Most of the monitoring data for the preconstruction and construction phases was obtained by District 09. TransLab performed some monitoring of the last construction project on Upper Sherwin Grade and made measurements on the channel change.

The final project selected for field study was on I-5 in south Sacramento County. This project closed the "gap" on the Mexico to Canada interstate route. Construction was scheduled to begin in late 1977. TransLab and District 03 made some measurements prior to, and during, the initial phases of construction. The project represented a typical construction job for the central valley region of California. Part of the project involved construction of a bridge over the Mokelumne River which empties into the San Joaquin-Sacramento River Delta system.

The winter of 1977-78 was above average in precipitation and ended the severe drought of the previous two years. Because of the extremely wet winter and significant run-off, monitoring on the three field studies continued until June 1978. Analysis of data and completion of the final report extended the research study beyond the scheduled completion date of June 1978.

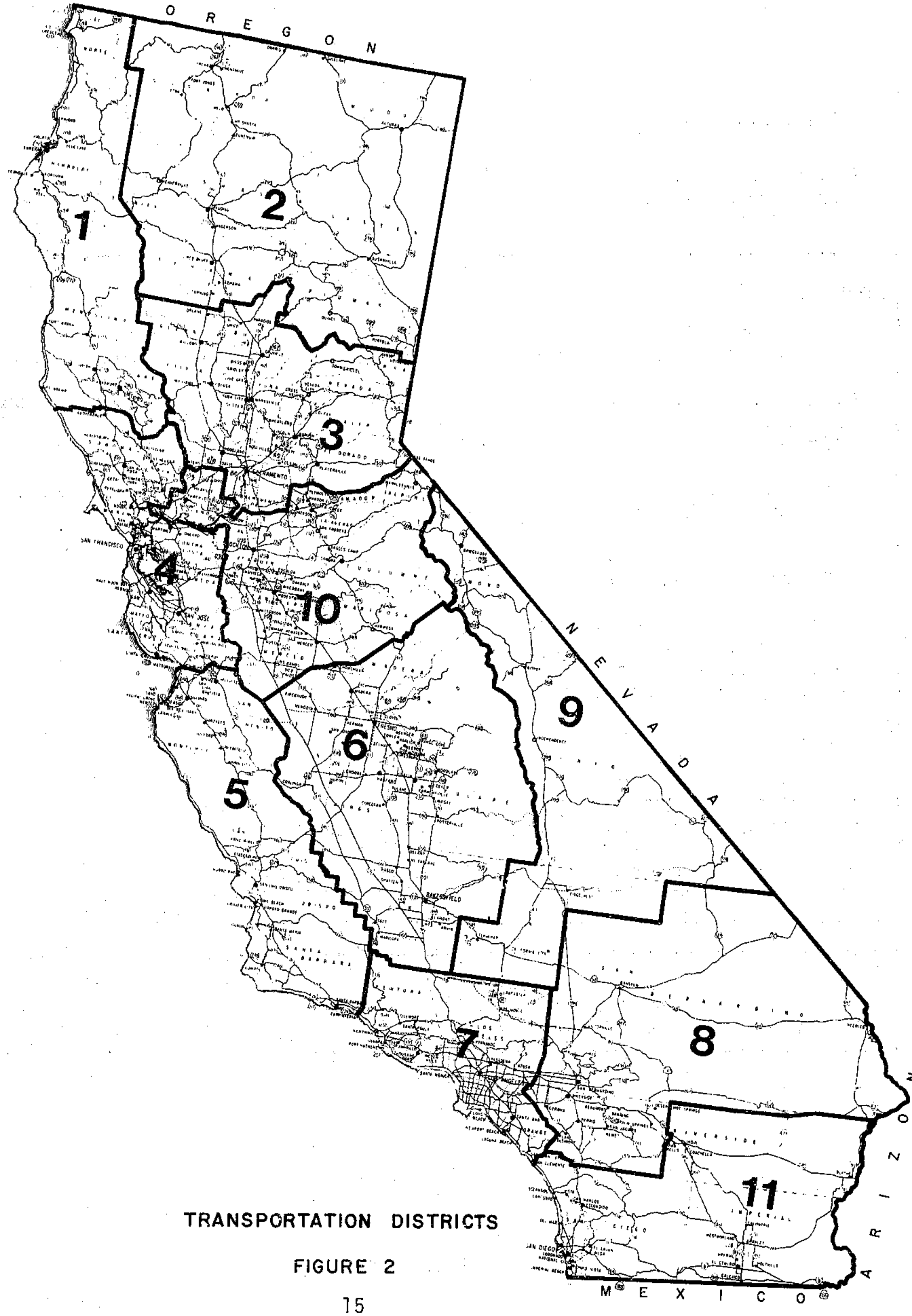
Before presenting details of the field investigations and results, it will be helpful to briefly review Caltrans environmental study procedures. This will help understand the procedures the Districts use to identify and forecast possible environmental impacts related to water quality.

DISCUSSION OF CALTRANS ENVIRONMENTAL STUDY PROCEDURES

In California, environmental studies for proposed projects are conducted by each of the eleven Caltrans Transportation Districts. The area covered by each of the districts is shown in Figure 2. The Headquarters Office of Environmental Planning and the Office of Planning and Design provide guidance in project development, and in the preparation and administration of environmental documents(1,2). The Headquarters Offices of Landscape and Architectural Design, Highway Maintenance, and Highway Construction, and the Division of Transportation Planning also provide guidance in their respective functional areas(3,4,5,6).

The Office of Transportation Laboratory (TransLab), Water Quality and Solid Waste Research and Development Section, provides technical assistance to the districts and Headquarters offices on water-quality related matters such as aquatic biology, fishery resources, chemical pollutants, bacteriology, erosion, sediment transport, solid waste, deicing salt effects on terrestrial and aquatic biota, and in the development of related mitigation measures.

Each of the eleven Transportation Districts have established an Environmental Planning Branch for designing, conducting, analyzing and reporting environmental studies for transportation projects. For each project, the District forms a Project Development Team that is interdisciplinary in nature(7). They help guide and coordinate the environmental study with Headquarters staff specialists in the various offices. Figure 3 shows the organizational structure in Caltrans as it pertains to water quality.



TRANSPORTATION DISTRICTS

FIGURE 2

Caltrans Organizational Structure pertaining to Water Quality

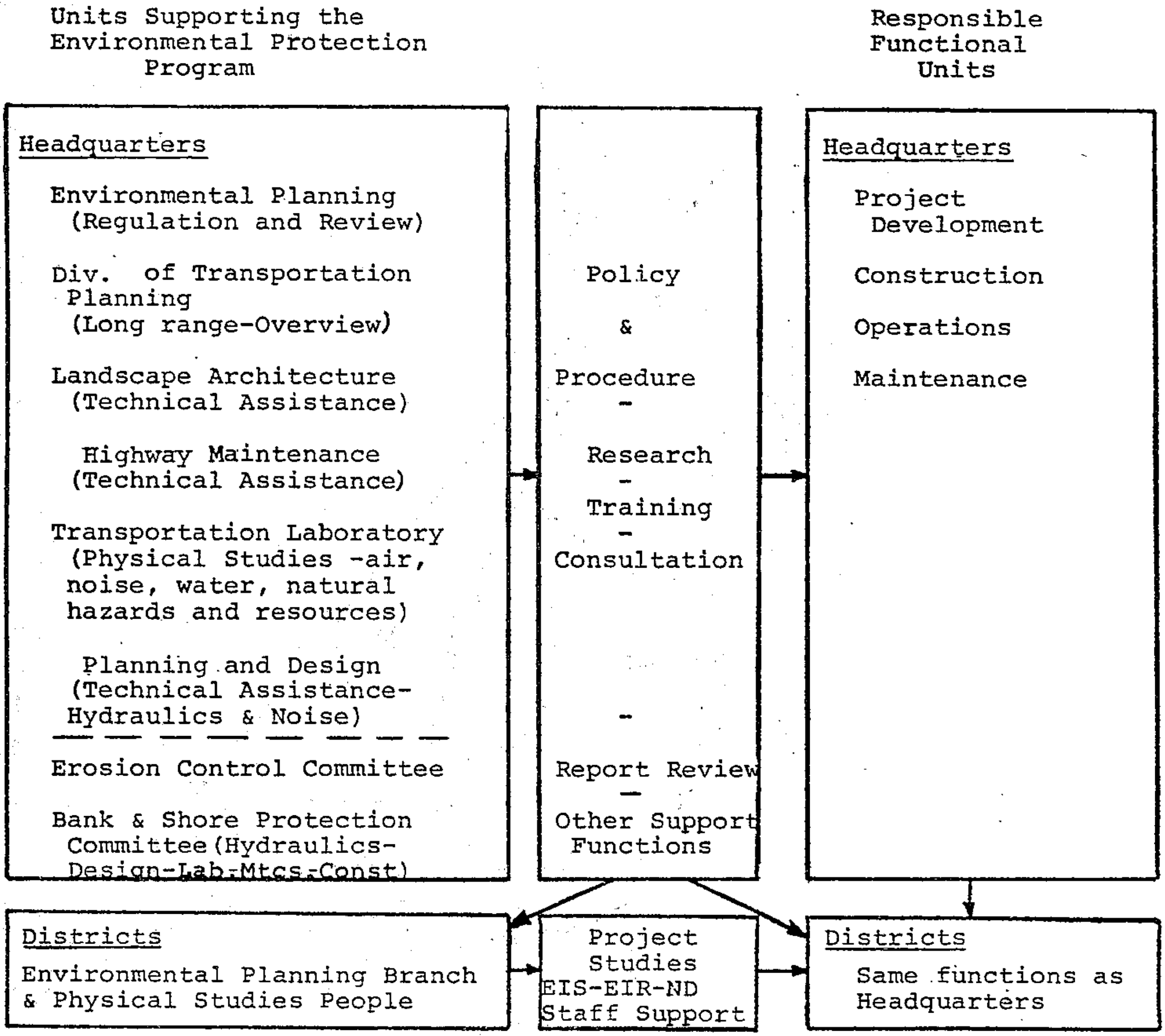


FIGURE 3

TransLab established guidelines in the form of a 4-volume Water Quality Manual to assist the districts in their investigations(8,9,10,11). These volumes were later expanded to a 5-volume Water Quality Manual by the Federal Highway Administration and updated to reflect advances in the state-of-the-art(12,13,14,15,16).

Water-quality studies and the associated field programs can be separated into three types depending on the functional level to which they apply and the nature of the contemplated work. The three basic types of studies include: 1) system planning, 2) project level (location and design), and 3) construction. The research was oriented to the project-level study and particularly those that encroach upon an aquatic feature or have the potential to influence a nearby body of water to some degree. The reason for the selection was based on the fact that the majority of draft environmental impact statements (DEIS's) being worked on by the Districts in the early to mid 1970's were largely projects that were already in the pipeline at the time the National Environmental Policy Act (NEPA) was passed and took effect in January 1970. More recently, the number of DEIS's being prepared have decreased and more Negative Declarations (ND's) are being prepared.

For project-level studies, the environmental investigation is focused on factors such as existing system hydraulics (stream regime and flow dynamics), hydrology (especially flow frequency and high-low flow relationships), lateral and vertical stability at proposed stream crossings, effects of channel changes on hydraulics and aquatic ecosystem, and sediment and chemical pollutant discharges. Figure 4 shows the component parts of a water-quality study.

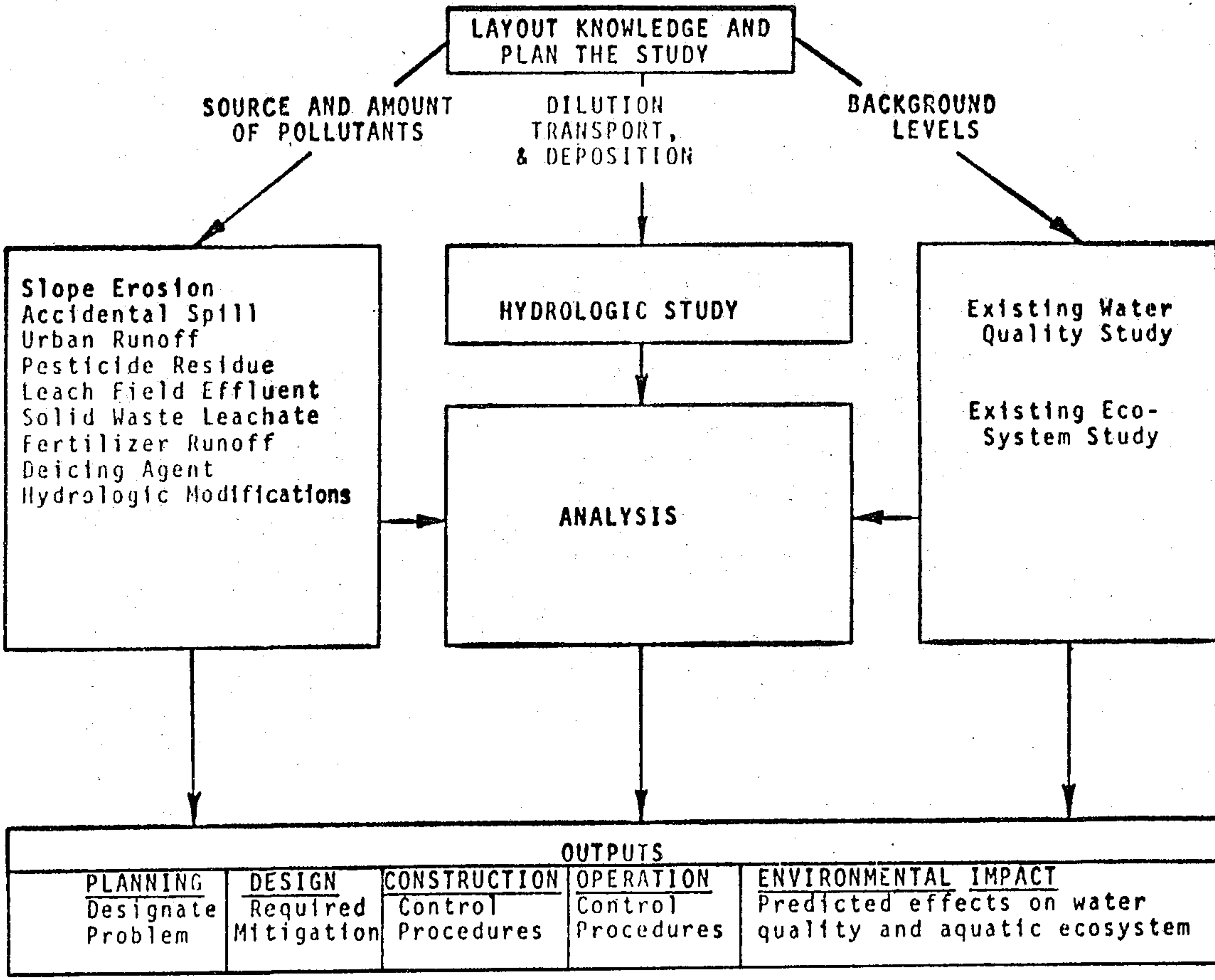


Figure 4, A Procedure for Analyzing Transportation System Impact on Water Quality

Mitigation of potential environmental impacts is designed into the project plans and specifications. Standard Specifications of Caltrans, Section 7-1.01L Water Pollution, require the contractor to submit a plan for water-pollution control before starting work to the resident engineer(17). The requirements of the water-pollution-control plan include the following:

> "Before starting any work on the project, the Contractor shall submit, for acceptance by the Engineer, a program to control water pollution effectively during construction of the project. Such program shall show the schedule for the erosion-control work included in the contract and for all water-pollution-control measures which the Contractor proposes to take in connection with construction of the project to minimize the effects of his operations upon adjacent streams and other bodies of water."

During the course of any construction project, operations may be temporarily halted if inadequate provision has been made for water-quality protection. Remedial work may be required to correct any impacted areas, and a revised water-pollution-control plan submitted for approval before resumption of operations.

Design plans designate features that must be incorporated into a project for water-quality protection. The Contractor is advised of these measures and they are installed as quickly as possible.

Specifications are prepared for each job to delineate activities and material requirements. For example, the maximum exposed area of erodible earth material at any one time in a given location is set at 750,000 square feet. Before additional acreage is opened up, either temporary or permanent erosion-control measures must be accomplished. Other provisions include:

"1. Where working areas encroach on live streams, barriers adequate to prevent the flow of muddy water into streams shall be constructed and maintained between working areas and streams, and during construction of such barriers, muddying of streams shall be held to a minimum.

2. Removal of material from beneath a flowing stream shall not be commenced until adequate means, such as a bypass channel, are provided to carry the stream, free from mud or silt, around the removal operation.

3. Should the Contractor's operations require transportation of materials across live streams, such operations shall be conducted without muddying the stream. Mechanized equipment shall not be operated in the stream channels of such live streams except as may be necessary to construction crossings or barriers and fills at channel changes.

4. Water containing mud or silt from aggregate washing or other operations shall be treated by filtration, or retention in a settling pond, or ponds, adequate to prevent muddy water from entering live streams.

5. Oily or greasy substances originating from the Contractor's operations shall not be allowed to enter or be placed where they will later enter a live stream.

6. Portland cement or fresh portland cement concrete shall not be allowed to enter flowing water of streams.

7. When operations are completed, the flow of the stream shall be returned as nearly as possible to a meandering thread without creating possible future bank erosion, and settling pond sites shall be graded so they will drain and will blend in with the surrounding terrain.

8. Material derived from roadway work shall not be deposited in a live stream channel where it could be washed away by high stream flows.

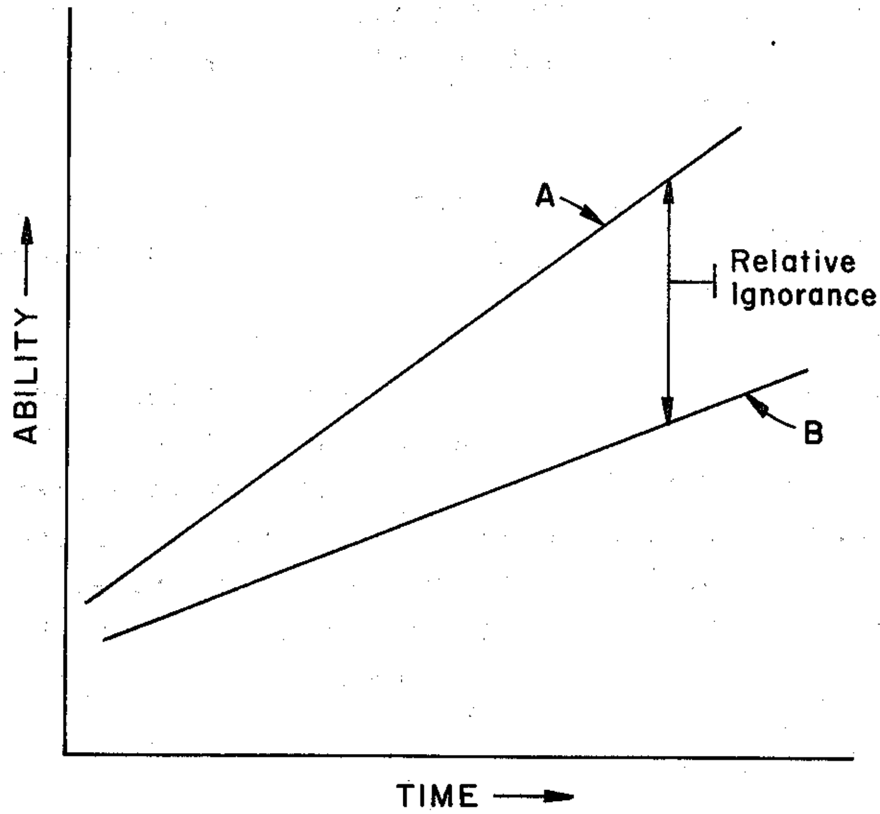
9. Where there is possible migration of anadromous fish in streams affected by construction on the project, the Contractor shall conduct his operations so as to allow free passage of such migratory fish."

In addition to the Caltrans specifications, permits must be properly secured and adhered to. Section 5650 and 12015 of the Fish and Game Code must be complied with(18). Other regulatory permits must be obtained and the stipulations adhered to. The Regional Water Quality Control Boards issue water discharge permits under the requirements of Public Law 92-500 (Water Pollution Control Act Amendments) and the California Porter-Cologne Water Quality Act.

Given the above background information, this TransLab research was undertaken to study the influence of highways on water-quality and to confirm the adequacy of present district and Headquarters procedures for studying potential water quality impacts associated with proposed projects and the delineation of specific mitigation measures. When performing environmental studies for future projects, there is always a certain degree of projected impact that may or may not be totally accurate. The ability to predict the future rests with the adequacy of current prediction methods, environmental conditions that are in constant change, and input variables that are assumed because of a lack of knowledge concerning their exactness. Figure 5, from a report by Oregon State University under a study for the Office of Water Research and Technology, depicts the situation of attempting to forecast the future in comparison to the ability to produce environmental change(19).

As the state-of-the-art in analyzing and predicting future water-quality impacts improves, the band between predicted and actual environmental responses will become smaller.

The Caltrans research attempted to study portions of three highway construction projects to compare the predicted water-quality interactions with what actually occurred. The information will be useful in the continuation of certain Caltrans procedures and modifications to others where appropriate.



A = Ability to produce environmental change.
B = Ability to forsee environmental change.

ABILITY TO PREDICT FUTURE ENVIRONMENTAL CHANGE

FIGURE 5

INTERSTATE 5, DUNSMUIR (HEDGE CREEK)

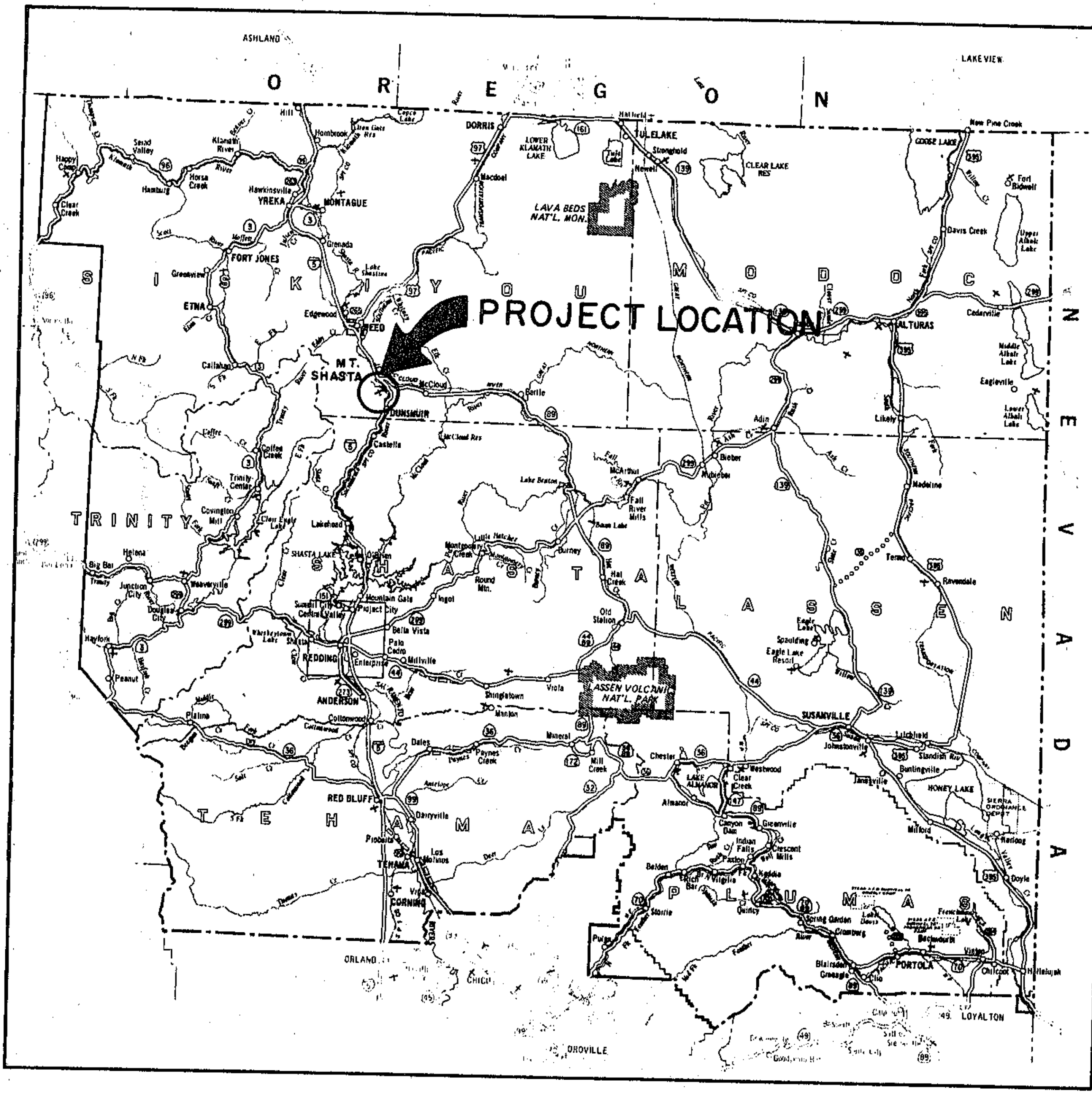
The I-5 Dunsmuir project was located in Northern California in Siskiyou County (see Figure 6). The project consisted of converting 6.3 miles of existing four-lane expressway into a six-lane freeway from Dunsmuir north to just south of Mt. Shasta City (see Figure 7). Interstate 5 is a major north-south artery in California and is heavily used for commerce and travelers. Mt. Shasta, elevation 14,165 feet, is just north of the project location and provides a majestic view for the traveler.

The project lies at the 3,500-foot elevation. Average annual precipitation is about 50 inches with the majority of it falling as snow.

Hedge Creek originates to the east of the project and flows southwesterly towards the Sacramento River. The Sacramento River flows southerly and empties into Lake Shasta, located about 30 miles to the south, where the water is stored and later released for agriculture, industrial, recreation, fish and wildlife, navigation, and power generation under the Central Valleys Project of the U.S. Bureau of Reclamation.

Flows have not been recorded in Hedge Creek but estimates are that the average 10-year flow is about 500 cfs. Low flows approach 1 cfs or less. The Hedge Creek Watershed is about 2.6 square miles and is in mountainous terrain with a mixed deciduous-coniferous forest (see Figure 8).

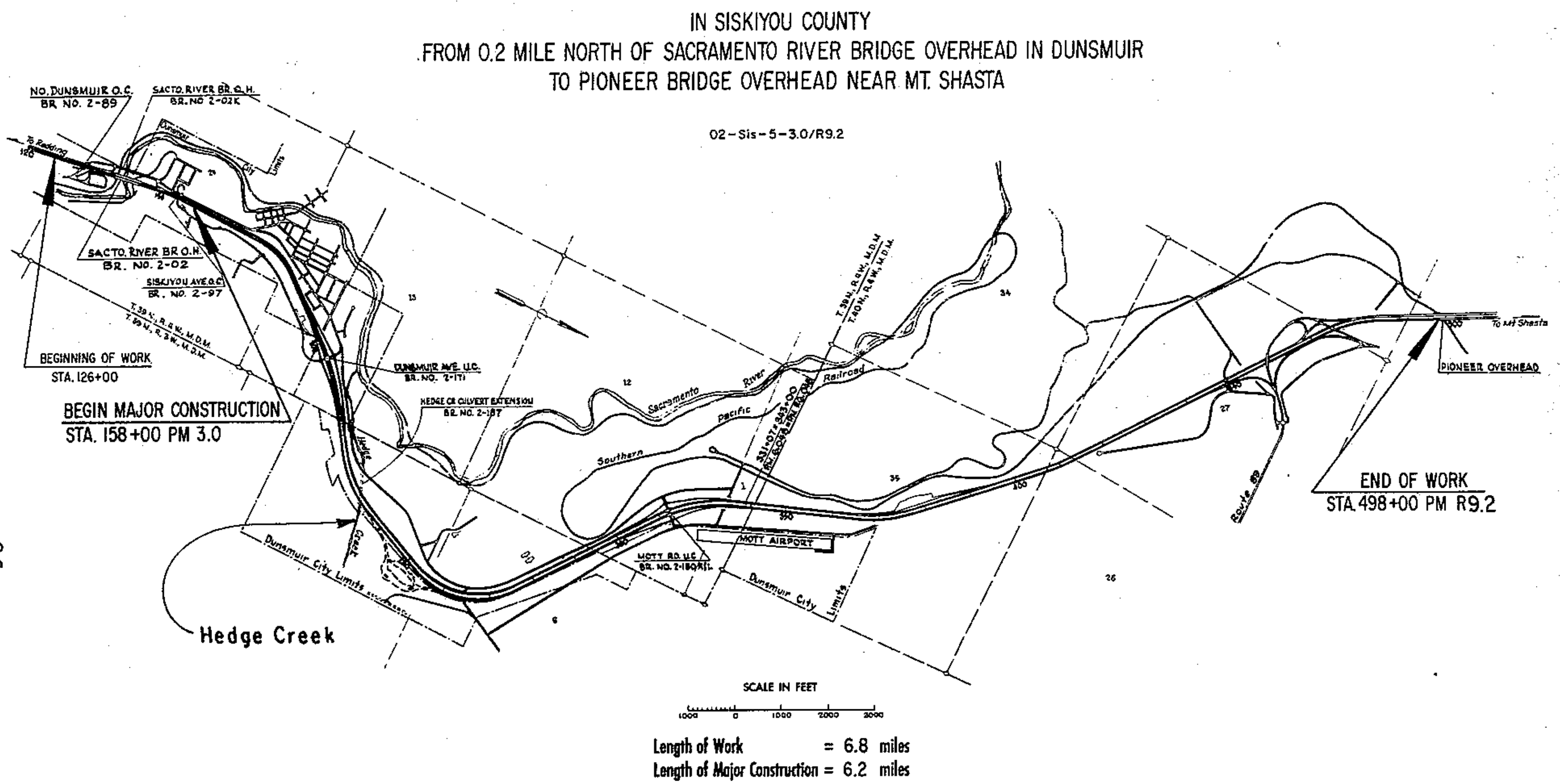
The creek flows under I-5 through a reinforced concrete arch culvert near the southern end of the project. Then it flows parallel to the roadway for about 1/4 mile before



LOCATION MAP

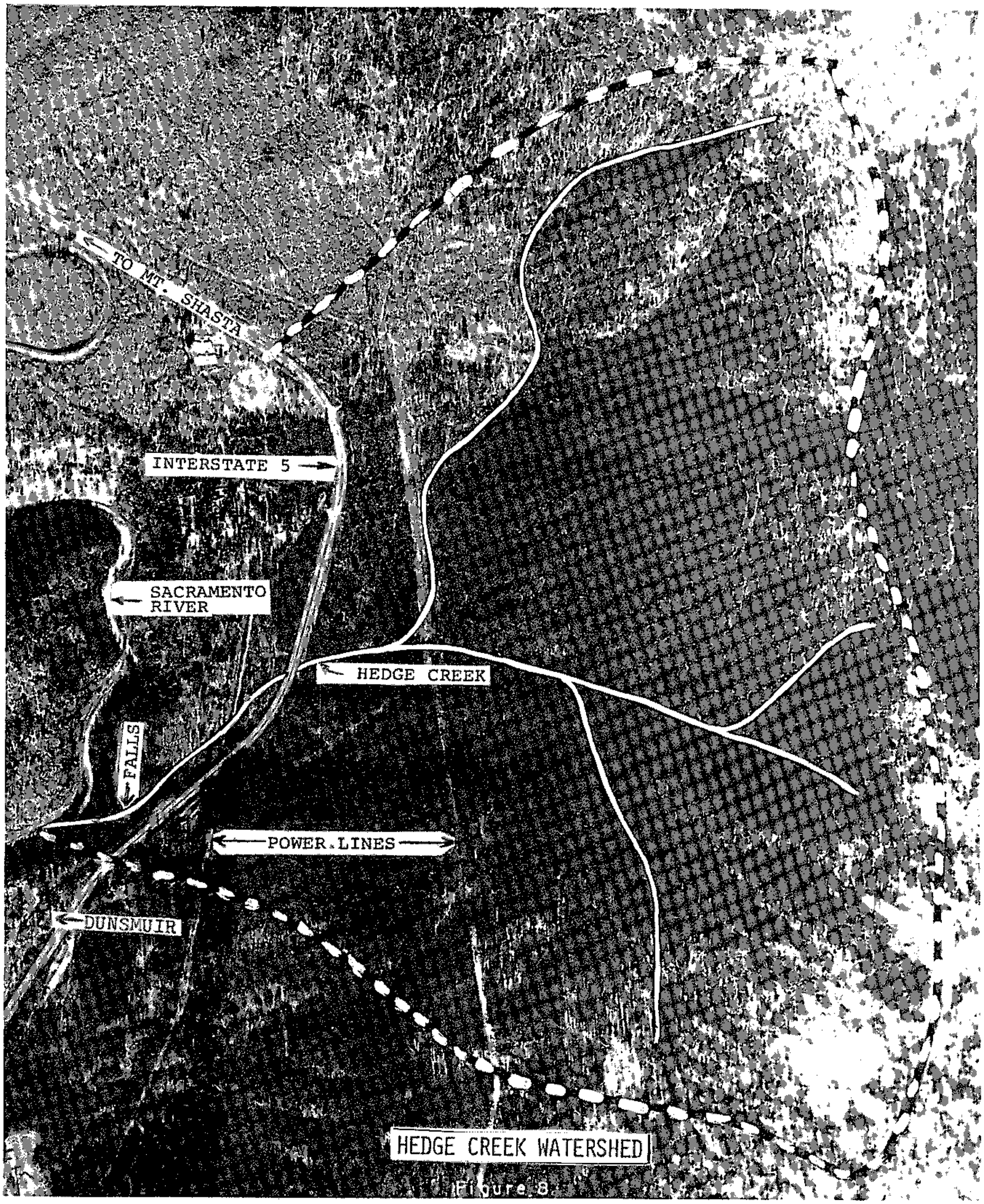
I-5 DUNSMUIR (HEDGE CREEK)

FIGURE 6



CONSTRUCTION LIMITS I-5 DUNSMUIR

FIGURE 7


TO MT. SHASTA
INTERSTATE 5
SACRAMENTO RIVER
HEDGE CREEK
FALLS
POWER LINES
DUNSMUIR
HEDGE CREEK WATERSHED
Figure 8

it veers off towards the Sacramento River, which is about one mile to the southwest.

Just as Hedge Creek veers away from the project, it flows over "Hedge Creek" falls, created by a 40-foot high cathedral-like formation nestled in the dense forest (see Photos 1 and 2). The falls present a beautiful natural setting and was the subject of much concern by local citizens and various groups in the initial stages of project development. The roadway alignment was shifted to the east to avoid contact with the "falls" as a result of these concerns.

In moving the alignment to the east, a cut slope on the existing roadway was increased 1.5 acres in size. The vulnerability of the enlarged slope face to erosion resulted in the undertaking of a specialized revegetation study by Dr. Andrew Leiser of the Department of Horticulture, University of California at Davis. Based on previous studies conducted with Caltrans(20,21), Dr. Leiser developed a revegetation plan for the slope. The treatment was monitored as part of the research.

The channel realignment included extending the existing reinforced concrete arch culvert 90 feet to the west and then constructing a new channel for about 500 feet parallel to the frontage road.

Photo 1
Hedge Creek Falls During
Winter High Flows

Photo 2
Hedge Creek Falls During Drought

Environmental Study (Preconstruction)

Preconstruction data were collected from March 1973 through May 1974 for the environmental assessment by the District 02 Environmental Planning Branch. Four preconstruction sampling sites were established on Hedge Creek for physical and chemical water quality parameters as shown in Figure 9. The locations of the sites were as follows:

Site 1 was about 2,000 feet upstream from the highway.

Site 2 was about 450 feet upstream from the highway.

Site 3 was just below the project and above hedge Creek Falls.

Site 4 was about 200 feet below Hedge Creek Falls.

A Water-Quality Report was completed by the District 02 staff(22). A summary of the data from that study is shown in Table 2.

The largest daily variation in air temperature from one site to the next was 17°C, occurring during September 1973. The largest variation in water temperature was 9.5°C, occurring during August 1974. In general, the water and air temperatures indicated the same trends and did not have a consistent difference between sites. The maximum difference between summer and winter temparatures for air was about 30°C and for water, about 15°C. The temperature measurements were made according to Calif. Test Method 734(23).

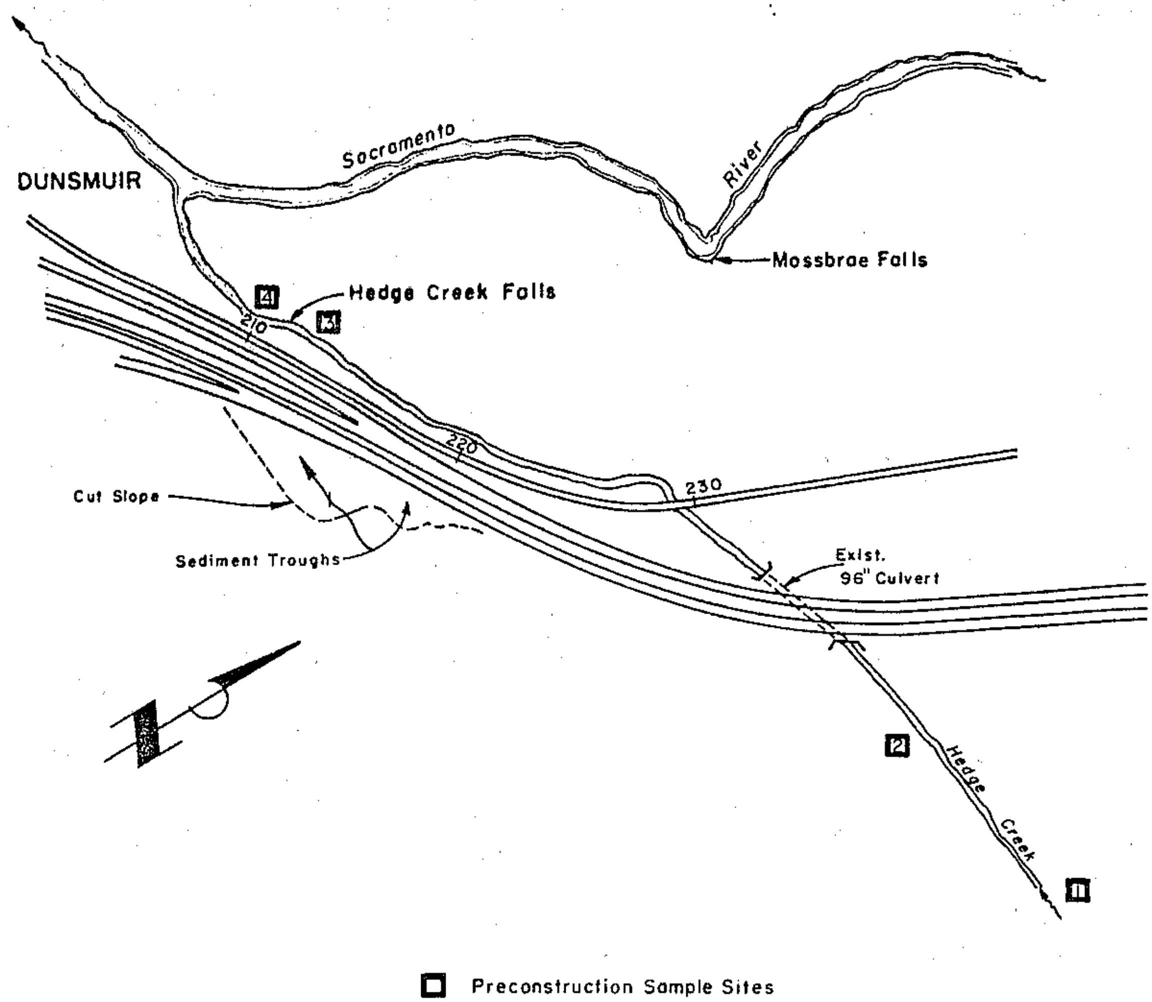

DUNSMUIR
Sacramento
River
Mossbrae Falls
Hedge Creek Falls
210
220
230
Cut Slope
Sediment Troughs
Exist.
96" Culvert
Hedge
Creek
Preconstruction Sample Sites

FIGURE 9

SUMMARY OF PRECONSTRUCTION WATER QUALITY DATA

Parameter	Site 1 Ave.	Site 1 Range	Site 2 Ave.	Site 2 Range	Site 3 Ave.	Site 3 Range	Site 4 Ave.	Site 4 Range	Water* Quality Criteria (25)	Sacramento* River Basin Standards (26)
Air Temperature (°C)	10.3	-3 - 28	9.0	-3 - 29	8.1	-1 - 20	10.2	-1 - 23	-	-
Water Temperature (°C)	6.6	1 - 15	6.3	1 - 15	6.7	2 - 13	7.0	2 - 15	A	B
Turbidity (JTU)	7.1	0.6 - 73	6.0	0.5 - 68	6.6	0.4 - 71	7.1	0.3 - 73	-	C
Hardness (Mg/l)	46.7	25 - 80	51.8	25 - 90	47.3	25 - 70	64.6	15 - 170	-	-
Sulfate (Mg/l)	3.8	1 - 8	4.2	1 - 8	5.3	2 - 10	4.1	0 - 7	D	-
Nitrate (Mg/l)	5.0	0.2 - 17.2	2.0	0.2 - 6.2	1.8	0.3 - 5.0	2.6	0.3 - 9.2	E	-
Alkilinity (Mg/l)	57.5	30 - 70	49.1	30 - 70	51.8	30 - 70	75.4	35 - 230	F	-
Chloride Ion (Mg/l)	4.8	0 - 10	3.6	0 - 7.5	7.0	0 - 25	16.9	0 - 90	G	-
Dissolved Oxygen (Mg/l)	10.8	8.5 - 12.0	10.8	8.6 - 12.0	10.2	6.1 - 12.2	10.7	7.4 - 12.1	H	I
Saturated Dissolved Oxygen (Mg/l)	11.2	9.4 - 12.8	11.3	9.7 - 12.8	11.2	9.7 - 12.5	11.2	9.8 - 12.5	-	-
pH	7.6	6.9 - 8.0	7.6	7.1 - 8.0	7.5	6.9 - 7.9	7.5	6.4 - 8.3	J	K

*NOTES:

A - For cold-water streams, the temperature of the water should not be increased by more than 5°F. The normal daily and seasonal temperature variations that were present before the highway project should be maintained. The recommended temperature for spawning and egg development of trout is 55°F.

B - Temperature changes due to controllable factors shall be limited as follows (maximum temperature shall be): 55°F from December 1 to March 15; 60°F from March 16 to April 15; 65°F from April 16 to May 15; 70°F from May 16 to October 15; 65°F from October 16 to November 15; 60°F from November 16 to November 30.

C - Where natural turbidity is between 0 and 50 Turbidity Units, 50 and 100, and greater than 100, the increases shall not exceed 20%, 10 Turbidity Units, and 10%, respectively.

D - 95% of waters that support good fish life have less than 90 mg/l of sulfates.

E - 95% of waters that support good fish life have less than 4.2 mg/l of nitrates.

F - The alkalinity is not lethal to fully developed fish in natural waters when its concentration is insufficient to raise the pH will above 9.0. Interference with normal development and other damage to fish life may occur, however, at lower pH levels.

G - 400 mg/l is harmful to trout.

H - To sustain a coarse fish population, the dissolved oxygen concentration may be less than 5 mg/l for a period of not more than 8 hours out of any 24 hour period, but at no time shall the concentration be lower than 2 mg/l.

I - The monthly median of the mean daily dissolved oxygen concentration shall not fall below 85% of saturation in the main water mass and the 95 percentile concentration shall not fall below 75% of saturation. The dissolved oxygen concentration shall not be reduced below 7.0 mg/l at any time.

J - The range tolerated by most fresh water fish is 6.5 to 8.4.

K - The pH shall not be depressed below 6.5 or raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5.

Turbidity measurements (Calif. Test Method 731) were generally low except on November 30, 1973, when there was a heavy rainfall. After grading operations started, measurements below Hedge Creek Falls were higher than those taken upstream from the construction area.

Hardness measurements (Calif. Test Method 742) on July 2, August 6, and September 4, 1973, at location 4 below Hedge Creek Falls were higher than the other locations. There does not appear to be a consistent trend between seasons or between sites.

Sulfate measurements (Calif. Test Method 748) prior to construction did not indicate any trends and were not consistent between sites. Measurements during construction indicated high values below Hedge Creek Falls on August 21 and September 17, 1974. The measurement on October 8, 1974 indicated sulfates were about at the preconstruction level.

Nitrate measurements were high on May 2, July 2 and August 6, 1973, and then leveled off to very low values thereafter. There were no consistent differences between test sites. Nitrate measurements were taken with a Portable Direct-Reading Engineers Water Testing Laboratory (DREL) Kit manufactured by Hach Chemical Company.

Alkalinity was high on July 2, August 6 and September 4, 1973, at Site 4 (below Hedge Creek Falls). The reason for this is not known. An overall decrease in alkalinity occurred during the winter months for all test sites. There does not appear to be any consistent differences between test sites. Alkalinity measurements were taken with the DREL kit.

Chloride measurements (Calif. Test Method 740) were high on July 2, August 6 and September 4, 1973, at Site 4 (below Hedge Creek Falls). This is similar to the high alkalinity measurements for these dates and the reason for this is not known. In addition there was a high test on November 30, 1973, at Site 3 (above Hedge Creek Falls) and on August 21, 1974 at Site 2 (upstream above construction area). The reason for this is not known.

Salt applied in the vicinity of Hedge Creek during the winter of 1973-74 was estimated at 10 tons/mile. The chloride tests did reflect the application of salt used for de-icing of highways at Sites 3 and 4.

The lowest dissolved oxygen (D.O.) measured (Calif. Test Method 733) was during August 1973, and the highest on January 7, 1974. There was no consistent difference between sites but the data indicated high D.O. during winter and some low D.O. during summer. Dissolved oxygen measurements taken at various intervals indicate near saturation levels, indicating a healthy aquatic environment.

Initial pH readings (Calif. Test Method 747) on May 2, and June 4, 1973, showed the lowest pH readings but generally seemed to stabilize around 7.6 for the remaining period. There was no consistent difference between sites.

The two locations where erosion was monitored with sediment troughs are shown on Figure 9. This cut slope is a mesozoic basic intrusive formation composed of very fine-grained impermeable clay soil and broken rock resting on hard lava flows. This soil type is classified as moderately erodible. Preconstruction slope-erosion data were obtained with sediment collection troughs (Photos 3 and 4).

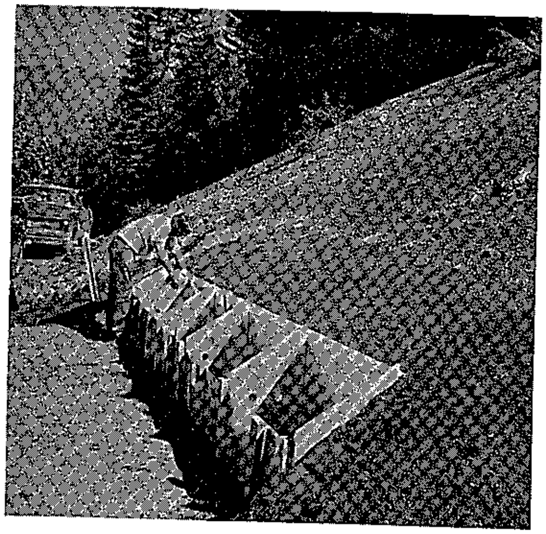


Photo 3
Installation of Sediment
Trough at Site 1

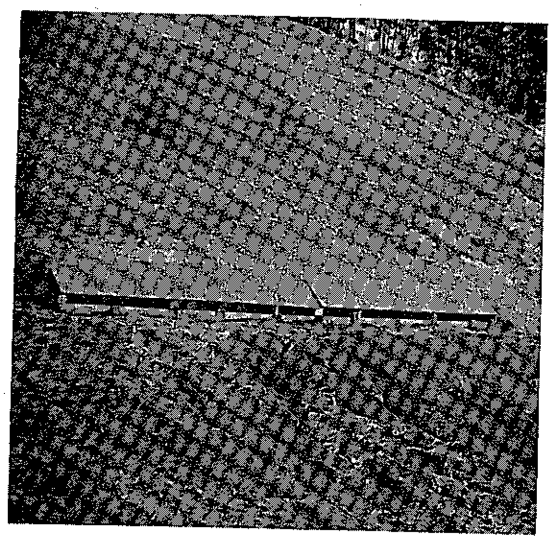


Photo 4
Sediment Trough at Site 2

A recording-precipitation gage was installed at the Mount Shasta Maintenance Station, located 1.5 miles north of the slope. The gage recorded 87 inches of precipitation (rain and snow) during October 12, 1973, through June 30, 1974. During this same period, sediment equivalent to 10 tons per acre was collected at Site 1 located towards the north end of the slope and 21 tons at Site 2 on the south end. Sediment from the troughs was collected 6 times, during the test period. Each time the wet and dry weights and grading of the soil were determined. Precipitation amounts were also recorded. Tables 3 and 4 show the sediment and precipitation during the preconstruction test period. The average annual precipitation in this area is about 50 inches, much falling as snow.

In early 1973, a service agreement was established with the Department of Environmental Horticulture, University of California, Davis (UCD), for Dr. Andrew Leiser, Professor, to develop a revegetation plan for this large cut slope. Field survey and trial plantings were made by Dr. Leiser in March and April 1973. In May 1973, Dr. Leiser submitted a revegetation plan for this slope. The plan contained a list of native vegetation found in the area. The installation of willow cuttings and willow wattling was also recommended. Dr. Leiser's recommendations were used to develop the erosion control section of the special provisions for this construction project. Most of the revegetation recommendations were derived from on-going Caltrans research with the University and U.S. Soil Conservation Service in the Lake Tahoe Basin.

TABLE 3

PRECONSTRUCTION SEDIMENT COLLECTION SITE 1 (NORTH)

Date of Measurement	Precipitation, inches		Sediment, lbs (dry)		Sediment Yield* tons/acre	
	P	ΣP	WT	ΣWT	Y	ΣY
10/31/73	7.28	7.28	26.4	26.4	0.70	0.70
11/21/73	21.62	28.90	265.1	291.5	7.01	7.71
12/3/73	7.71	36.61	41.3	332.8	1.09	8.80
12/31/73	6.15	42.76	5.0	337.8	0.13	8.93
1/28/74	15.51	58.27	23.4	361.2	0.62	9.55
5/30/74	28.54	86.81	28.2	389.4	0.75	10.30

*This trough collected sediment from an area of approximately 822 sq ft (0.0189 acre).

TABLE 4

PRECONSTRUCTION SEDIMENT COLLECTION SITE 2 (SOUTH)

Date of Measurement	Precipitation, inches		Sediment, lbs (dry)		Sediment Yield* tons/acre	
	P	ΣP	WT	ΣWT	Y	ΣY
10/31/73	7.28	7.28	5.7	5.7	0.13	0.13
11/21/73	21.62	28.90	372.6	378.3	8.35	8.48
12/3/73	7.71	36.61	79.2	457.5	1.78	10.26
12/31/73	6.15	42.76	1.9	459.4	0.04	10.30
1/28/74	15.51	58.27	404.1	863.5	9.06	19.36
5/30/74	28.54	86.81	95.5	959.0	2.14	21.50

*This trough collected sediment from an area of approximately 973 sq ft (0.0223 acre).

No aquatic-biota samples were taken prior to the re-channelization of Hedge Creek. However, the preconstruction condition of the stream would indicate that the biota would be typical of a small woodland stream. Species with short larval life cycles, such as Ephemeroptera, certain Diptera, Plecoptera, Tricoptera, and hardy species of Coleoptera probably predominated because of low water conditions during the dry portion of the year. Probably very few species requiring greater than one season of larval development occurred.

In 1971 the California Department of Fish and Game electrofished 900 feet of channel above Hedge Creek Falls and found 13 trout ranging in size from 2-1/2 to 9-1/2 inches. Additionally, during field observations by Caltrans personnel, trout were observed in the stream before and during construction.

Factors that may have lowered productivity in the stream are rapid fluctuation in stream level during storms and periodically high fine sediment transport from upstream disturbances. Because the watershed is very small and the terrain steep, storm runoff accumulates rapidly in the stream and velocities are high. This effect causes some bottom instability and scour making biological life difficult during the winter storm periods. The stream is also subject to influx of silts from logging and utility and road construction in the watershed. These are yearly occurrences in this watershed.

The Environmental Impact Statement (EIS), prepared by District 02, was submitted on November 30, 1973(22). Several probable unavoidable adverse effects with regard to water quality, aesthetics and fishery were identified in the EIS. These are discussed below:

"By moving the alignment to the east, an additional 1.5 acres of surface area will be exposed on the large cut slope located near Hedge Creek. This additional area, unless mitigated by vegetation, could have an aesthetic effect on the traveling public as well as local citizens.

Soil erosion from the slopes near Hedge Creek during construction could cause sedimentation in Hedge Creek, prior to significant plant growth on the slopes.

A potential threat exists to the Hedge Creek fishery from sedimentation resulting from newly exposed cut slopes. In addition, noxious materials which could result from spills during construction can find their way into the stream. During construction of the channel change, an effect on fish may result from the siltation."

Several mitigation measures were brought out in the District's EIS to minimize or eliminate the probable unavoidable adverse effects discussed in the previous section. These are discussed below:

"1. The surface area of the large cut slope is proposed to be approximately 5 acres, an increase of 1.5 acres from the existing slope. In order to minimize the aesthetic and erosion effects, a research project to develop a plan for revegetation was instituted. A horticulturist at the University of California, at Davis, Dr. Andrew Leiser was contracted as a consultant to determine the best methods of establishing native vegetation on the denuded slope.

2. To minimize sedimentation in Hedge Creek from soil erosion and construction practices during the construction period, the contractor was required to submit a plan to the resident engineer for approval that included features as check dams, sediment basins, etc. A provision was included that no area larger than 750,000 square feet be exposed at any one time without erosion-control measures and temporary planting of grass cover.

3. To combat the threat to the Hedge Creek fishery, all mitigation measures described in paragraph 2 were to be enforced. In addition, the Standard Specifications concerning work near a live stream would be enforced. The resident engineer and the State Department of Fish and Game would be in continual contact regarding the contractor's operation near the stream.

Construction of the new 500 foot channel alignment in late spring or early summer would minimize the impacts, because during these periods the stream flow is very low (approximately 1 cfs), and the erosion and siltation from the channel diversion should be slight. The new channel alignment would be lined with rock to relieve scouring. The banks of the new channel would be planted with willow cuttings to restore stream-edge vegetation and hasten the recovery of the habitat."

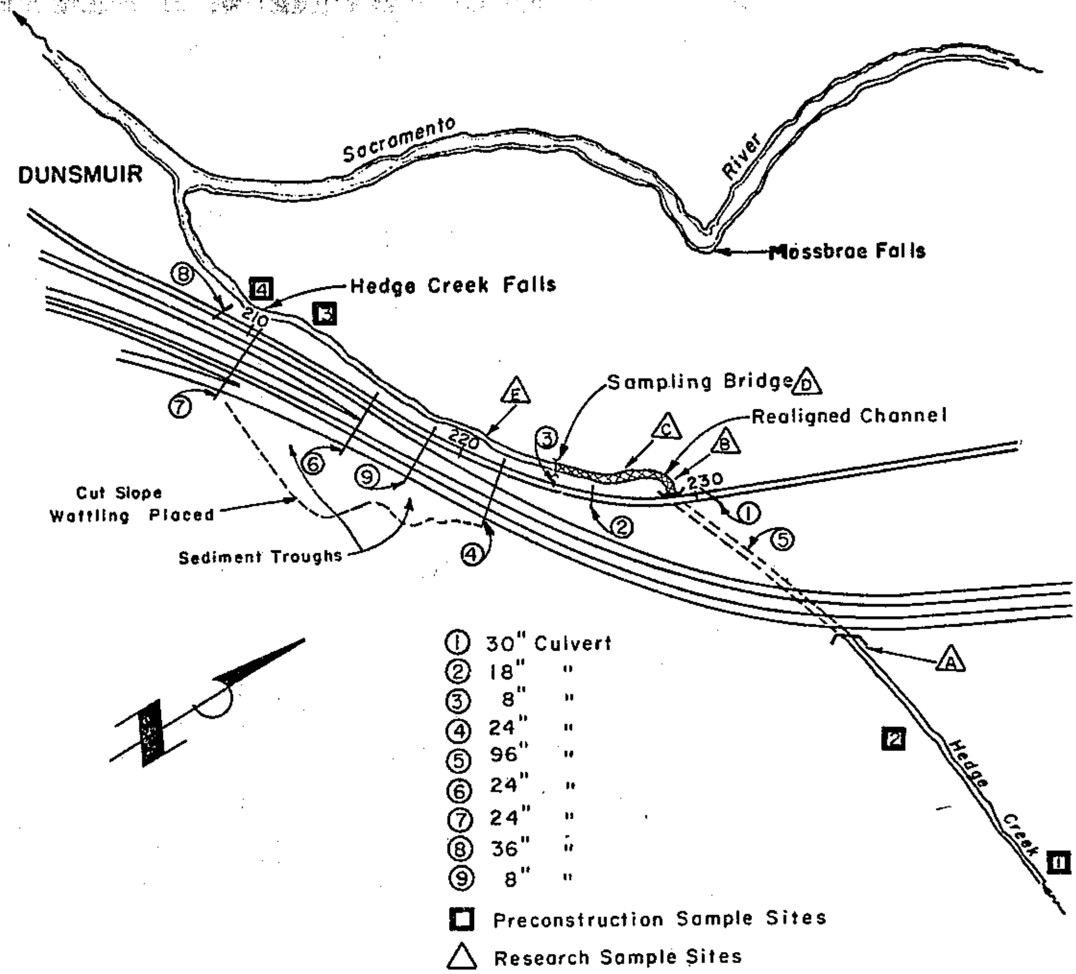
Construction Monitoring

The construction monitoring period was from June 1974, through December 1976. A drought occurred during the winters of 1975-76 and 1976-77(24). The average annual precipitation for the Hedge Creek area is about 50 inches. The total precipitation for the 1975-76 and 1976-77 water years was 22.79 inches and 22.76 inches, respectively. During the summer months, the flow in Hedge Creek was very low and subsurface flow occurred in realigned portions of the stream.

Due to the drought, there was limited water-quality monitoring during construction. No samples were taken from October 1974, through September 1975, due to very low flows. Water analyses, from October 1975, through December 1976, were limited to only a few parameters, due to the continuation of the drought. The sampling sites are shown on Figure 10.

Temperatures, taken from October 1975, through May 1976, indicate very little change in temperature of the water as it travels from Site A to Site E. The temperature of the water increased in the denuded realigned portion of the stream during the hot summer months. Measurements were not taken during the 1976 summer due to very low flows.

The stream was monitored for turbidity during 16 storms in the 2 years of construction. The data is shown in Table 5. The turbidity during light rain periods did not increase appreciably from Site A to Site E, although the turbidity was slightly lower at Site A (control) than at those sites along the realigned portion of the stream. Data from a storm on April 7, 1976, as shown in Table 6, indicated



CONSTRUCTION SAMPLING SITES

FIGURE 10

TABLE 5

TURBIDITY MEASUREMENTS DURING CONSTRUCTION

Date	Days Since Last Storm	Storm Duration (hrs)	Precip. (in.)	Average Flow (cfs)	Turbidity (NTU)* A	B	C	D	24" CSP**	E
10/27/75	13	11	0.57	0.15	1	-	-	6	-	-
10/28/75	2	6	0.05	0.15	1	-	-	2	-	-
2/17/76	1	12	0.35	0.15	.7	.9	3.4	4.1	-	-
2/19/76	2	5	0.78	0.15	2	-	13	18	-	-
3/5/76	2	2	0.47	0.40	-	-	-	5	-	40
3/12/76	5	.25	0.02	0.35	-	-	-	1.6	29	3
3/18/76	10	11	0.24	0.30	33	32	36	33	-	56
3/22/76	4	.5	0.02	0.30	-	-	-	1.8	5.4	2.6
3/24/76	2	4	0.10	0.30	-	-	-	2.4	33	3.1
3/31/76	7	7	0.44	0.25	-	44	-	56	-	-
4/2/76	7	7	0.44	0.25	-	-	-	-	920	96
4/7/76	5	16	1.65	0.25	57	437	171	174	528	280
4/8/76	1	26	1.94	0.60	5	10	9	11	57	12
4/12/76	1	3	0.04	0.60	2.4	2.6	3.3	3.9	13	4.6
5/17/76	21	1.5	0.17	0.25	-	-	-	1.2	8.9	1.3
6/9/76	6	1	0.05	0.10	-	-	-	3	13	12

*NTU = Nephelometric Turbidity Unit.

**The 24" corrugated steel pipe (Culvert #4, Figure 10) is located approximately 100 feet below sample Site D.

TABLE 6

TURBIDITY READINGS DURING ONE STORM
(April 7, 1976)

Hedge Creek

	Turbidity (NTU)					
Time (hrs)	A	B	C	D	24" CSP	E
0900	29	152	204	153	228	195
1330	57	437	171	174	528	280
1515	418	1,353	992	992	1,887	1,147

higher turbidities at Sites B through E, than at Site A. Turbidity of samples taken from the outlet of Culvert 4 was consistently higher than for samples from any of the other sites. Due to the influence of Culvert 4, turbidity at Site E was slightly higher than at Site D. Photos 5 and 6 shows the source of the sediment that enters Hedge Creek via Culvert 4.

Chloride ion measurements were taken for 17 storms during construction. The data are shown in Table 7. Analysis of chloride data for 4 specific storms is presented in Table 8. Chloride measurements indicate high concentration at Culvert 4, but reduced concentrations at Site E probably due to dilution. According to the Mount Shasta maintenance foreman, during the 1975-76 Winters approximately 7 tons of deicing salt (sodium chloride) were applied to 1.04 miles of roadway that drain into Hedge Creek. No salt was applied in the 1976-77 winter.

Hourly measurements for a period of 24 hours were made to determine the daily temperature cycle of the water flowing through the rechannelization. Additionally, dissolved oxygen, conductivity and pH readings were taken. The dates, locations and parameters measured are listed in Table 9. No measurements were made during the 1976 summer due to very low flows.

During the construction of the 96-inch diameter culvert to convey Hedge Creek, an underground spring was discovered. Three 12-inch diameter culverts were installed to discharge the spring flows into the main culvert at about the midpoint. The spring water was colder than the Hedge Creek water. Because the initial flow from the springs was higher than the stream flow, the colder water had a pronounced effect on

Photo 5

Sediment From Eroding Fill Slope Running Down the Gutter (December 1977)

Photo 6

Sediment Entering This Drop Inlet Which Enters Hedge Creek via Culvert 4 (December 1977)

TABLE 7

CHLORIDE ION MEASUREMENTS DURING CONSTRUCTION

					Site Reading (mg/l)					
Date	Days Since Last Storm	Storm Duration (hrs)	Precip. (in.)	Average Flow (cfs)	A	B	C	D	24" CSP*	E
2/17/76	1	12	0.35	0.15	.25	.34	.34	.34	-	-
2/19/76	2	5	0.78	0.15	.30	.30	.39	.44	-	-
2/25/76	6	20	0.79	0.30	-	.64	-	1.77	-	-
2/27/76	1	16	3.08	2.10	-	.44	-	.94	-	-
3/5/76	2	2	0.47	0.40	-	-	-	.34	-	4.04
3/12/76	5	.25	0.02	0.30	-	-	-	.20	2.02	1.23
3/18/76	10	11	0.24	0.30	.15	.15	.15	.24	-	3.06
3/22/76	4	.25	0.02	0.30	-	-	-	.39	3.40	.63
3/24/76	2	4	0.10	0.30	-	-	-	.39	11.80	1.75
3/31/76	7	7	0.44	0.25	-	.29	-	2.67	-	-
4/2/76	7	7	0.44	0.25	-	-	-	-	-	9.91
4/7/76	5	16	1.65	0.25	.15	3.74	2.48	2.57	7.43	3.50
4/8/76	1	26	1.94	0.60	.24	13.84	2.33	2.28	30.45	3.40
4/12/76	1	3	0.04	0.60	0	.19	.29	.39	4.03	.44
5/17/76	21	1.5	0.17	0.25	-	-	-	.97	.97	.87
6/9/76	6	1	0.05	0.10	-	-	-	1.44	1.05	.86
7/19/76	26	1	0.13	0.10	-	-	-	3.54	-	-

*24" CSP located 100 feet below Site D.

TABLE 8
CHLORIDE ION READINGS DURING SPECIFIC STORMS

Date	Time (hrs)	A	B	C	D	24" CSP*	E
		Site Reading (mg/l)					
3/18/76	1130	.15	.15	.15	.24	-	3.06
3/18/76	1340	.05	.05	0	.10	-	.73
3/22/76	1210	-	-	-	.39	3.40	.63
3/22/76	1245	-	-	-	.49	217	6.56
3/24/76	1430	-	-	-	.39	11.8	1.75
3/24/76	1445	-	-	-	.34	29.72	2.33
4/7/76	0945	.58	1.41	2.62	2.23	8.69	3.74
4/7/76	1335	.15	3.74	2.48	2.57	7.43	3.50
4/8/76	1000	.24	13.84	2.33	2.28	30.45	3.40

*24" CSP located 100 feet below Site D

TABLE 9
SUMMARY OF 24 HOUR MEASUREMENTS FOR SELECTED PARAMETERS

Date	Temperature	Dissolved Oxygen	pH	Conductivity	Location*
6/3/75	X				A,B C,D,E
7/9/75	X	X	X	X	A,B,C,D,E & 4
8/13/75	X	X	X	X	A,B,C,D,E & 4
10/25/75	X	X			A & D
1/28/76	X	X			D
5/17/76	X	X			D

*See Figure 9 for locations.
Sites A-E are Construction Locations.
Site 4 is a Preconstruction Location

the stream temperature. For example, on July 8, 1975, stream temperatures were recorded for a 24-hour period. During this period, the temperature of the spring flows was constant at 7.7°C. The flow from the springs accounted for 60% of the total stream flow. The temperature of the stream at the culvert inlet was 13.2°C (measured at 3:30 p.m.). The temperature at the culvert outlet, below the point of inflow from the springs, was 10.2°C. Flows from the spring varied during the study and they eventually ceased during August 1975.

Temperature increases along the rechanneled stream section were also observed. As a result of the rechannelization, all riparian vegetation was removed exposing the flows to direct solar radiation. The highest recorded rise in temperature was 5°C. The maximum temperature measured at the end of the rechanneled section was 16°C. This was low enough not to interfere with the life cycle of biological organisms. A longer rechanneled section could have resulted in higher temperatures which could have been detrimental. Vegetation incorporated along the channel banks later provided sufficient shade to negate any adverse temperature effects.

Twenty-four hour dissolved oxygen (D.O.) measurements indicated high concentrations, the lowest readings being 8.9 mg/l on June 17, 1976, with the majority of measurements ranging between 10 and 12 mg/l. The high D.O. levels throughout the creek will support almost all aquatic organisms. There were no distinctive trends in D.O. levels as the water traveled through the rechannelization.

Twenty-four hour pH values ranged from 6.5 to 8.0. There were no distinct trends as the water traveled through the rechannelization.

Twenty-four hour conductivity measurements indicated a slight increase as the water travels through the rechannelization. Increases ranged from 1 to 16 micromhos per centimeter. Maximum recorded conductivity was at 1500 hours.

Because of the drought (low flows) and the problem of arriving at the jobsite during peak flow periods during a storm, only four sets of suspended-sediment samples were taken. The results of these samples are shown in Table 10. The data show that Hedge Creek carries a high sediment load during storm periods.

Preconstruction slope erosion data on the existing large cut was monitored from October 12, 1973, through July 12, 1974. The two sediment-collection troughs were removed on July 12, 1974 due to reconstruction of the slope. After reconstruction of the slope, the troughs were replaced and sediment collection commenced again (Photos 7 and 8). Sediment collection for the period of construction was from June 12, 1975, through May 16, 1977. Due to the drought, minimal erosion occurred. The troughs were emptied only 4 times. The total accumulated sediment and precipitation for this period are shown in Table 11. For comparison, the sediment and precipitation data for the preconstruction period also are shown.

TABLE 10

SUSPENDED SEDIMENT TRANSPORT
FOR SELECTED PERIODS IN
HEDGE CREEK

Date	Flow (cfs)	Suspended Sediment Concentration (mg/l)	Suspended Sediment Transport (tons/day)	Weather
2/27/76	1.5	517	2.09	Showers
4/7/76 (1400 hrs)	0.5	2,420	3.27	"
4/7/76 (1530 hrs)	0.7	2,839	5.37	"
4/8/76	1.3	66	0.23	Light Showers

Photo 7
Replacing the Sediment-
Collection Troughs

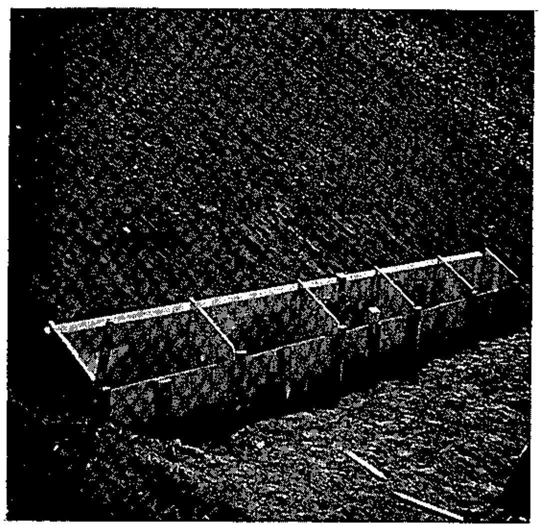


Photo 8
Sediment-Collection Trough

TABLE 11

SEDIMENT AND PRECIPITATION DATA
FOR LARGE CUT

During Construction	Σ Sediment tons/acre	Σ Precipitation inches
Site 1	4.52	37.96
Site 2	4.70	37.96
Preconstruction		
Site 1	10.30	86.81
Site 2	21.50	86.81

It should be noted that during the placement of the willow wattling in July 1975, and other vegetation in November 1976, soil on the slope was loosened; this accounts for some of the erosion. Due to this problem and the lack of precipitation, no conclusions can be made for this period.

Various mitigation measures were implemented on this project to protect the water quality of Hedge Creek. Most of the measures are items cited in the Special Provisions or Standard Specifications (Sec. 7-1.01L). The asphalt and fiberglass roving ditch linings for control of ditch erosion were completed under a contract change order.

To control erosion and subsequent impacts to the water quality from sediment, the Contract Special Provisions included items for erosion control as follows:

> "10-1.15 EROSION CONTROL.--Erosion control shall consist of applying straw, seed and fertilizer to embankment slopes; cultivating, fertilizing, seeding and applying nozzle-placed fiber mat to selected excavation slopes; stylize planting of native trees and shrubs to selected excavation slopes and planting vines in reinforced earth embankments as specified in Section 20, "Erosion Control and Highway Planting," of the Standard Specifications and these special provisions, as shown on the plans and as directed by the Engineer.
>
> GENERAL.--Commercial fertilizer shall conform to the provisions in Section 20, "Erosion Control and Highway Planting," of the Standard Specifications and these special provisions.
> Commercial fertilizer shall have the following quaranteed minimum chemical analysis:

Ingredient	Percentage Minimum
Nitrogen	16
Phosphoric Acid	20
Water-soluble Potash	0

Commercial fertilizer (Type 2) shall be a slow release type and shall be in compact tablet form approximately 5 grams per tablet, with the following guaranteed minimum chemical analysis:

Ingredient	Percentage Minimum
Nitrogen	20
Phosphoric Acid	10
Water-soluble Potash	5

Seed shall consist of the following:

Botanical Name (Common name)	Pounds per acre	Percentage (Minimum) Germination	Percentage (Minimum) Purity
Agropyron riparium (Sodar Streambank Wheatgrass)	20	80	90
Festuca ovina 'duriscula' (Durar Sheep Fescue)	15	85	95
Dactulis glomerata 'palestine' (Palestine Orchardgrass)	15	80	85
Arctostaphylos patula (Greenleaf Manzanita)	3	*	*
Ceanothus integerrimus (Deer Brush)"	3	*	*

Specifications for treatment of the seed were provided in the Special Provisions.

For application of the straw, the Special Provisions were as follows:

> "Straw shall be new. Stable bedding straw shall not be used.
>
> When weather conditions are suitable, straw may be pneumatically applied by means of equipment which will not render the straw unsuitable for incorporation into the soil.
>
> Straw shall be applied evenly over the embankment slope area to be stabilized at the total rate of approximately 3 tons per acre (slope measurement).
>
> After the straw is incorporated in the soil, seed at the rate of 56 pounds per acre (slope measurement) and fertilizer at the rate of 300 pounds per acre (slope measurement) shall be applied."

Application of the fertilizer, seed, and mulch was specified as follows:

> "Commercial fertilizer, at the rate of 300 pounds per acre, shall be applied to the excavation slopes shown on the plans or as directed by the Engineer and shall be mixed into the slopes approximately 3 to 6 inches deep.
>
> After the application and mixing of fertilizer into the slopes, the seed mixture shall be placed on the slopes by any method which will produce an even distribution at the rate of 56 pounds per acre, except that distribution by nozzle-planting method will not be permitted. The seeded and fertilized area shall be rolled to consolidate the slope before the application of fiber.
>
> After seeding and rolling the excavation slopes, fiber shall be applied uniformly to the slopes, in a slurry, at the rate of 1,200 pounds per acre."

large and diverse populations in streams with flows less than 1 cfs. The macroinvertebrate populations adjust to alternating wet and dry periods by being either exceptionally hardy or having short life cycles. In each case, the substrate was unaffected.

Hedge Creek was subjected to heavy siltations prior to the drought which severely restricted the habitat available during and after the drought. Even after water levels returned to normal, the silt and sand limited the recolonization of Hedge Creek.

The total decrease in macroinvertebrate populations can be attributed to both the drought and siltation. The length of time to recover, however, has been greatly extended by the heavy siltation. The silt and sand deposits in the creek came during construction. If normal rainfall had occurred during this period, the silt may have been washed out of the stream and little effect would have been observed.

An example of this effect can be seen in the results from site 7, sample periods I and II where silt from road construction had damaged the site prior to sample period I and it had not recovered by sample period II. The aquatic macroinvertebrate population can recover rapidly from environmental damage, but only if the stream habitat recovers first.

more than two feet in length and shall be placed randomly in each bundle so that approximately half the butt ends are at each end of the bundle. Bundles shall be tied on maximum 15-inch centers with two wraps of binders twine using a non-slipping knot. When compressed firmly and tied, each bundle shall be between 6 and 10 inches in diameter at its widest point.

Wattlings shall be placed on the slopes as shown in Figure 11 on Sheet PP-6. The bottom stakes shall be a maximum of 18 inches on center and the diagonal stakes through the wattlings shall be a maximum of 36 inches on center. Where wattling overlap occurs between bottom stakes, an additional bottom stake shall be used at the midpoint of the overlap. A diagonal stake shall also be placed through the overlapped portion of each bundle. Wattling shall be placed from the bottom of the slope, upward and each row will be covered with soil. Workers shall walk on wattling rows when placing successively higher layers. A maximum 10 percent of each wattling shall be left exposed after completion of the installation of wattlings in any area.

Stakes used for securing wattlings to the cut slopes shall be live willow stakes one inch minimum diameter or "Con" stakes (2 inches by 4 inches by 24 inches or 2 inches by 4 inches by 36 inches, diagonally cut). All stakes shall be driven to a firm hold and a minimum of 18 inches deep. Where soils are soft and 24-inch stakes are not solid (i.e., if they can be moved by hand), 36-inch stakes shall be used. Where soils are so compacted that 24-inch stakes cannot be driven 18 inches, 1/2-inch diameter reinforcing bar 18 inches long shall be used for stakes.

Wattling will be measured and paid for by the linear foot in place with no allowance made for losses due to overlapping of individual bundles.

The contract price paid per linear foot for wattling shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in installing wattling, complete in place, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

WILLOW CUTTINGS.--Willow cuttings shall be prepared as shown on the plans or specified in these special provisions. The locations, quantity and spacing of the willow cuttings may be adjusted by the Engineer as necessary to meet field conditions.

Willow cuttings, to the extent available, may be taken from existing groves on State Highway right of way under permit if the Contractor elects. The State makes no guarantee that there will be sufficient cuttings available from existing groves on State Highway right of way to complete work. It will be the Contractor's responsibility to locate groves in which cutting will be permitted.

Willow cuttings shall be from new vigorous growth. The cuttings shall be approximately 12 inches long and from 1/2 inch to one inch in diameter. The tops shall be dipped in tar. Leaves and lateral branches shall be removed flush with the trunk of the cuttings with no damage to the buds or bark.

Willow cuttings shall be prepared 2-4 days before planting and placed with the bottom 1/2 (one-half) in water and kept in a shaded location.

Immediately before planting, the basal 1/2 inch shall be immersed for 5-10 sec. in a 2,000 ppm Indolebutyric acid solution (50:50, water-ethanol). This may be done in bundles of 25-50 if all cuttings are immersed. Cuttings shall be protected from drying while planting is in progress.

Holes shall be made perpendicular to the slope with a star drill, dibble or similar tool, cuttings will be placed to the bottom of the hole so that no more than 2 inches of cutting is above the soil level.

Willow cuttings shall be planted as shown in the Stylized Planting diagram on Sheet pp-6 of the plans.

At least 6 inches of the cutting shall be below the soil level. In case of rocky areas, any excess cutting above the soil more than 2 inches shall be cut off. The top of any cutting so shortened shall be retarred.

Cuttings shall be firmed in by using the planting tool adjacent to the cuttings so that the cutting is firm and cannot be readily pulled from the soil."

In addition to the seeding, willow wattling, and willow cuttings, seedlings and container plants were installed. The time limit for planting was after November 1 and before March 1. In addition, a schematic plan was developed to show the general placement of the various species on the "big cut" as shown in Figure 11.

Table 12 lists the mitigation measures implemented on this contract to prevent water pollution in Hedge Creek.

During the 1975 summer construction season, soil deposited on the roadway by construction was washed along the existing expressway into Culvert 7, which drains into Hedge Creek directly below the falls (Photo 9). Clay and silt from this daily operation covered the creek bottom and virtually eliminated the macroinvertebrates in the creek from the Falls to the Sacramento River.

In order to prevent further damage to the creek, a settling basin was constructed on July 8, 1975 (Figure 12, Settling Basin 1). All of the wastewater from the roadway entered the basin, and sediment was allowed to settle. This was effective in removing the soil particles before the water was discharged into Hedge Creek (Photo 10).

On February 23, 1976, another settling basin was constructed upgrade from the inlet of Culvert 1 (Figure 12, Settling Basin 2). This basin was needed to prevent sediment, originating from the construction project, from entering Hedge Creek. The capacity of the basin was approximately 40 cubic yards. During the period April 8 through April 12, 1976, 1.42 inches of precipitation were recorded and the basin had collected approximately 5.25 cubic yards of sediment. During the period February 23, 1976, through July, 1976 the basin was excavated twice.

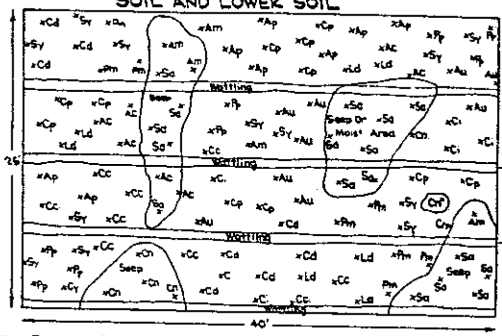
STYLIZED PLANTING DIAGRAM (SEE SPECIAL PROVISIONS)

REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

02 SIS	5	30/292	122

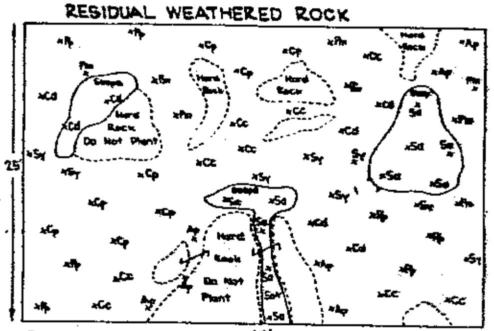
No. 10,698
JANUARY 7, 1974

"SOIL" AND LOWER SOIL



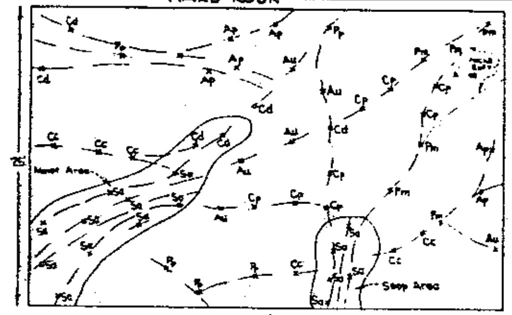
NOTE: PLANT SPACING APPROX. 3' O.C. (8 SQ. FT./PLANT).
LOCATION 3 USE STRAW MULCH IN LIEU OF WATTLING AND PLANTS SHALL BE APPROX. 6' ON CTR'S. (36 SQ. FT./PLANT).

RESIDUAL WEATHERED ROCK

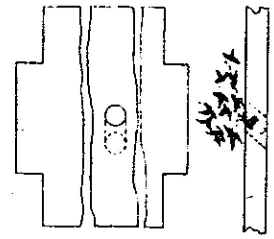


NOTE: PLANT SPACING APPROX. 4' O.C. (14 SQ. FT./PLANT)
PLANT IN CRACKS AND SOFT AREAS.

HARD ROCK



NOTE: PLANT SPACING APPROX. 4' O.C. (18 SQ. FT./PLANT.
PLANT IN CRACKS OR SOFT AREAS.



LOC. A & B PLANTING DETAIL
REINFORCED EARTH EMBANKMENT FACING

PLANT DISTRIBUTION PER THOUSAND SQ. FT. BY SPECIES AND SITE TYPE (TO NEAREST 0.1)

CODE	SPECIES, COMMON NAME	SOIL AND LOWER SOIL APPROX. 3' O.C.	WEATHERED ROCK APPROX. 4' O.C.	HARD ROCK APPROX. 4' O.C.
Ac	ABIES CONCOLOR, WHITE FIR	7.1	—	—
Cd	CALOCEDRUS DECURRENS, INCENSE CEDAR	8.2	7.0	5.8
Pp	PINUS PONDEROSA, PONDEROSA PINE	8.2	7.0	5.8
Pm	PSEUDOTSUGA MENZIESII, DOUGLAS FIR	8.2	7.0	5.8
Am	ACER MACROPHYLLUM, BIG-LEAF MAPLE	3.5	—	—
Ap	ARCTOSTAPHYLOS PATULA, GREENLEAF MANZANITA	8.2	7.0	5.8
Au	A. UVA-URSI, BEARBERRY	9.6	8.5	5.8
Cc	CEANOTHUS CORDULATUS, MOUNTAIN WHITETHORN	8.2	7.0	5.8
Ci	C. INTERGERRIMUS, DEER BRUSH	7.1	—	—
Cp	C. PROSTRATUS, SQUAW CARPET	11.0	8.5	7.3
Cn	CORNUS NUTTALLII, WESTERN DOGWOOD	7.1	—	—
Ld	LITHOCARPUS DENSIFLORA VAR. ECHINOIDES, DWARF TANOAK	7.1	—	—
Sy	SYMPHORICARPOS MOLLIS, SNOWBERRY	9.6	7.0	—
Sa	SALIX SP., WILLOW	16.4	10.9	14.5
	TOTALS	119.5	69.9	57.2

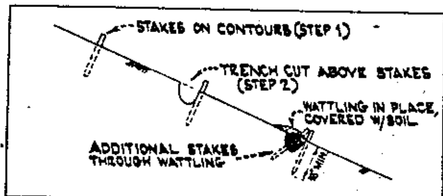


FIGURE 1-WATTLING INSTALLATION SCHEMATIC

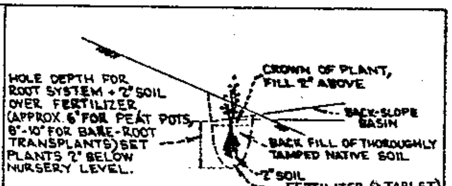


FIG. 2-SCHEMATIC OF PLANTING HOLES ON CUT SLOPE

SPECIES LISTED FOR REVEGETATION OF SLOPES

SPECIES	REMARKS	PLANT LIST	TYPE PLANT	LOCATION	SOIL*	WEATHERED ROCK	HARD ROCK	SEEPS	TOTAL
ABIES CONCOLOR WHITE FIR	TREE	J	BARE ROOT 2 OR 3 YRS.	1 2 3	1011 1085 244	NONE NONE NONE	NONE NONE NONE	OK OK OK	1011 1086 244
CALOCEDRUS DECURRENS INCENSE CEDAR	TREE	J	BARE ROOT 2 OR 3 YRS.	1 2 3	1145 1256 279	OK 450 OK	OK 270 OK	OK OK OK	1146 1976 279
PINUS PONDEROSA PONDEROSA PINE	TREE	J	BARE ROOT 2 OR 3 YRS.	1 2 3	1146 1256 279	OK 450 OK	OK 270 OK	OK OK OK	[illegible] 1976 [illegible]
ACER MACROPHYLLUM BIGLEAF MAPLE	TREE	I	PEAT POT	1 2 3	572 545 139	NONE NONE NONE	NONE NONE NONE	OK OK OK	[illegible] [illegible] [illegible]
PSEUDOTSUGA MENZIESII DOUGLAS FIR	TREE	J	BARE ROOT 2 OR 3 YRS.	1 2 3	1146 1256 275	OK 450 OK	OK 270 OK	OK OK OK	[illegible] 1976 [illegible]
ARCTOSTAPHYLOS PATULA GREENLEAF MANZANITA	SHRUB	I	PEAT POT	1 2 3	1146 1256 279	OK 450 OK	OK 270 OK	[illegible]	[illegible] 1976 [illegible]
ARCTOSTAPHYLOS UVA-URSI BEARBERRY	SHRUB	I	PEAT POT	1 2 3	1288 1485 312	OK 450 OK	OK 270 OK	[illegible]	[illegible]
CEANOTHUS CORDULATUS MOUNTAIN WHITETHORN	SHRUB	I	PEAT POT	1 2 3	1288 1265 312	OK 450 OK	OK 270 OK	[illegible]	[illegible]
CEANOTHUS INTEGERRIMUS DEER BRUSH	SHRUB	I	PEAT POT	1 2 3	1002 1075 243	NONE NONE NONE	NONE NONE NONE	NO NO NO	[illegible] 1075 243
CEANOTHUS PROSTRATUS SQUAW CARPET	SHRUB	I	PEAT POT	1 2 3	1574 1586 383	OK 560 OK	OK 368 OK	[illegible]	[illegible] [illegible] 383
CORNUS NUTTALLII WESTERN DOGWOOD	SHRUB	I	PEAT POT	1 2 3	1002 1094 244	NONE NONE NONE	NONE NONE NONE	OK OK OK	1002 1094 244
LITHOCARPUS DENSIFLORA VAR. ECHINOIDES, DWARF TANOAK	SHRUB	I	PEAT POT	1 2 3	1002 1094 244	NONE NONE NONE	NONE NONE NONE	NO NO NO	1002 1094 244
SYMPHORICARPOS MOLLIS SNOWBERRY	SHRUB	I	PEAT POT	1 2 3	1431 1472 347	OK 450 OK	NONE NONE NONE	OK OK OK	1431 1922 347
SALIX LASIOLEPIS OR S. MELANOPSIS, OR S. SCOULERIANA WILLOW	CUTTING) SHRUB	—	3/8"-3/4" DIA × 8"-10" LONG	1 2 3	2433 2500 582	OK 700 OK	OK 615 OK	OK OK OK	[illegible] [illegible] 582
*OK = PERMISSIBLE TO USE PLANT IN THESE AREAS.			TOTALS	1 2 3					17,183 25,489 4,178

SPECIES			TYPE PLANT	LOCATION	NUMBER
PARTHENOCISSUS TRICUSPIDATA BOSTON IVY	—	I	PEAT POT	A	420
"	—	I	"	B	450
				TOTAL	870

LOCATION	WATTLING
#1	23,000 LIN. FT.
#	22,500 LIN. FT.
#	NONE
TOTAL	45,500 LIN. FT.

PLANTING PLANS PP-6

037011.503

D. L. PERRY
C. R. YOUNG

GENERALIZED SCHEMATIC SHOWING PLACEMENT OF PLANTINGS ON BIG CUT
FIGURE 11

TABLE 12

PERMANENT MITIGATION MEASURES

Type	Location*	Quantity
Settling Basins**	At entrance of Culverts 1 & 8	-
Erosion Control		
Willow Wattling	Planting Locations 1 Planting Locations 2	12,800 lineal ft. 27,700 lineal ft.
Seed, Straw, Fiber & Fertilizer	Planting Locations 1, 2 & 3	See Special Provisions
Willow Cuttings	Planting Locations 1, 2 & 3	6,900 each
Container Plants & Seedlings	Planting Locations 1, 2 & 3	39,200 each
Ditch Lining		
Fiberglass Roving		5,800 lineal ft.
Asphalt Concrete (Paved)		2,200 lineal ft.
Hedge Creek		
Rock Channel Lining	In realigned channel	Approximately 500 ft.
Willow Cuttings	In realigned channel (500 ft.)	Various
Seeding of East Bank	Along realigned channel	56 lbs/acre
Seeding of West Bank	Along realigned channel	Various

*See Figures 13, 14 and 15 for Locations.

**Temporary mitigation measure, all others are considered permanent.

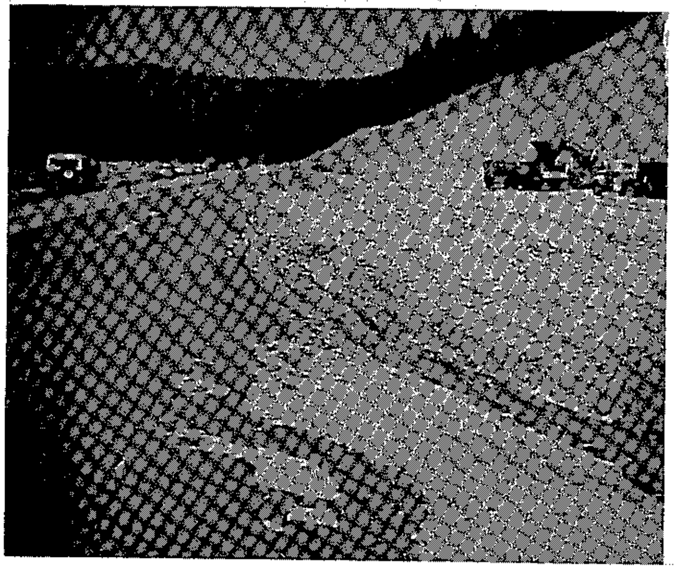


Photo 9

Wash Water From Daily Washing of the Existing Expressway During Construction

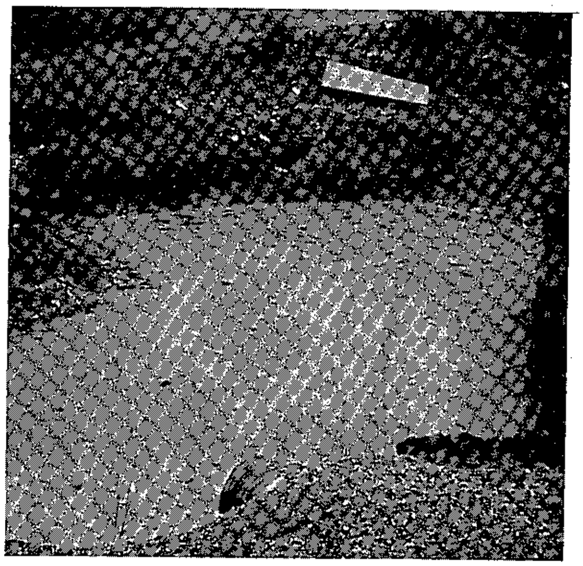
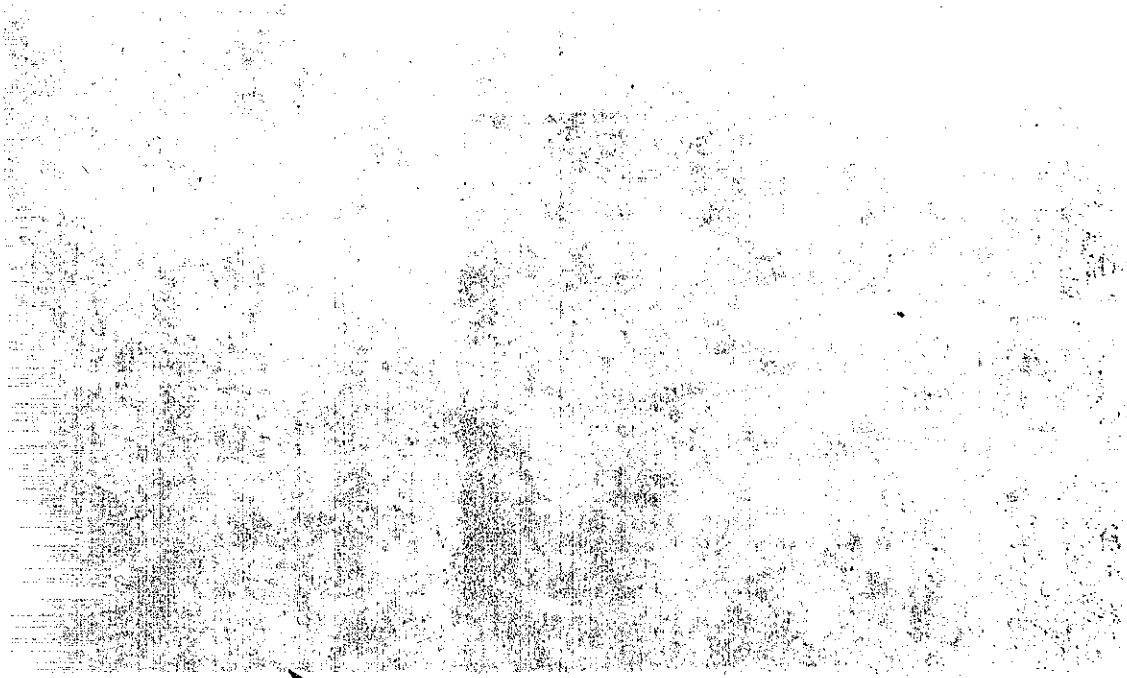
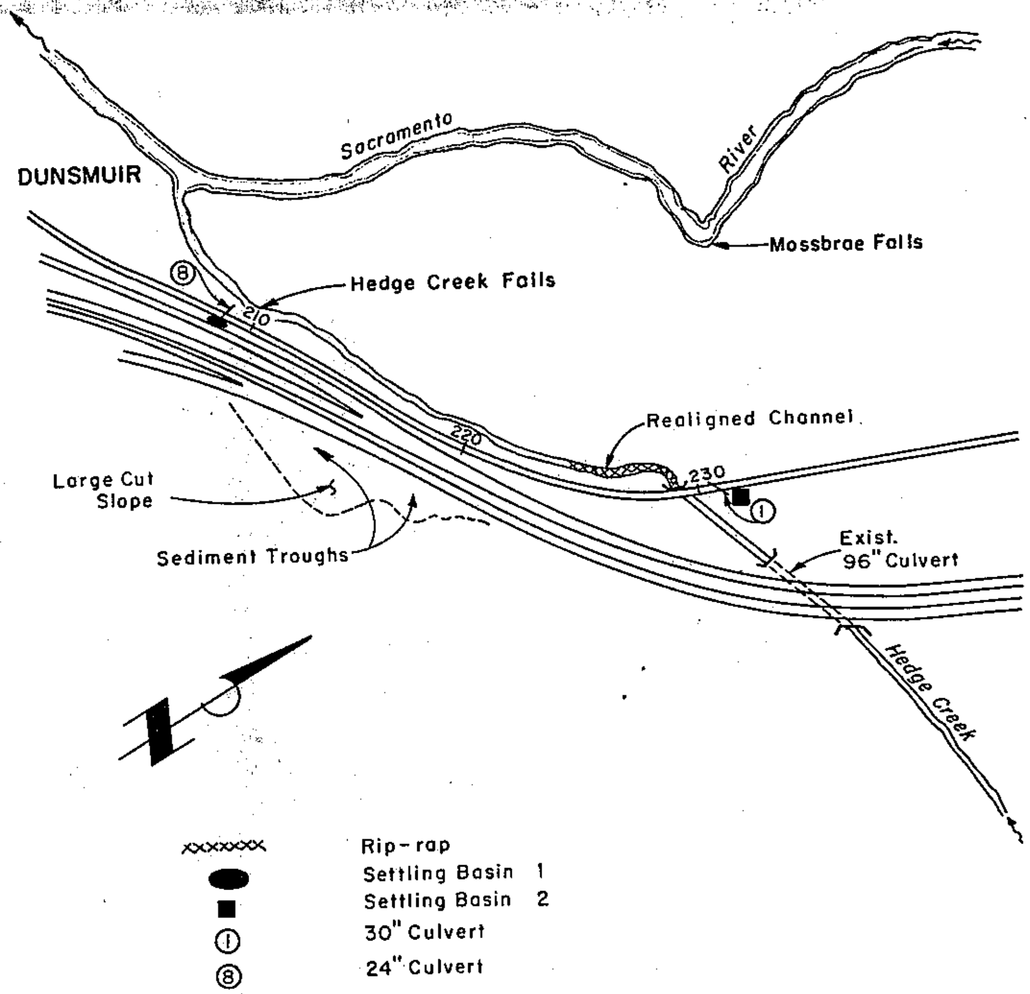


Photo 10

Settling Basin to Settle Out the Sediments Contained in the Wash Water





LOCATION OF
TEMPORARY SEDIMENT SETTLING BASINS

FIGURE 12

The construction of these simple sediment basins prevented a potentially large amount of sedimentation in Hedge Creek.

Preliminary design for the highway called for diverting Hedge Creek directly to Mossbrae Falls on the Sacramento River. Hedge Creek Falls, the canyon and the creek below the diversion were to be filled completely. Due to public opposition to removal of Hedge Creek Falls, a new alignment was proposed. This alignment saved Hedge Creek Falls, but required cutting another 100 feet into a large existing cut slope.

The existing cut slope had an area of about 3-1/2 acres and had suffered sheet and gully erosion since construction in 1959. A few trees and shrubs had become established on the slope through natural processes, but the vegetation was too sparse to reduce erosion.

The proposed cut slope was to have an area of about 5 acres, composed of four quite different types of materials. These were: "soil" (weathered soil or partially altered soil-forming materials), "lower soil" (soil-forming materials, well-decomposed rock), "weathered rock" (fragmented, soft rock, well fractured) and "hard rock". They constituted 25, 27, 35 and 13 percent of the cut slope respectively. The cut was designed for a 1-1/2 to 1 slope, with a 15-foot bench located about 60 feet up the face of the 200-foot slope.

The Special Provisions for this contract describe "Erosion Control", as applying straw, seed and fertilizer to embankment slopes; cultivating, fertilizing, seeding and applying nozzle-placed fiber mat to selected excavated slopes; stylized planting (schematic plan shown in Figure 11) of native trees and shrubs to selected excavation slopes. Stylized plantings included willow wattling, willow cuttings, seedlings and container plants. Planting procedures, plant spectrum and number were described earlier in this section in the Special Provisions and Planting Plan, sheet PP-6 (Figure 11). These were recommended by Dr. Andrew Leiser in a plan for revegetation developed for this contract.

There were three main planting locations on this contract (see Figure 13). Planting Location 1 is located below the Hedge Creek Watershed, having no influence on Hedge Creek. Location 2 is the large cut slope, altered due to the realignment to save Hedge Creek Falls. Location 3 is a fill slope located between the ultimate southbound lanes and the frontage road. The slopes at Locations 2 and 3 were potential threat to Hedge Creek since several drop inlets were located at the toe of these slopes. These inlets connect to culverts that carry runoff water into Hedge Creek. To protect Hedge Creek from turbidity, suspended sediments and nutrients, a revegetation plan was necessary.

Willow wattling consists of tied bundles of freshly cut willow branches. The bundles are laid into trenches dug on contours along the slope face, staked into position and backfilled with soil. The wattling acts as a sediment catchment and reduces the development of rills caused by concentration of flows. The willows can root and become a permanent stabilizing cover(20,21). This was the first installation of willow wattling on a contract.

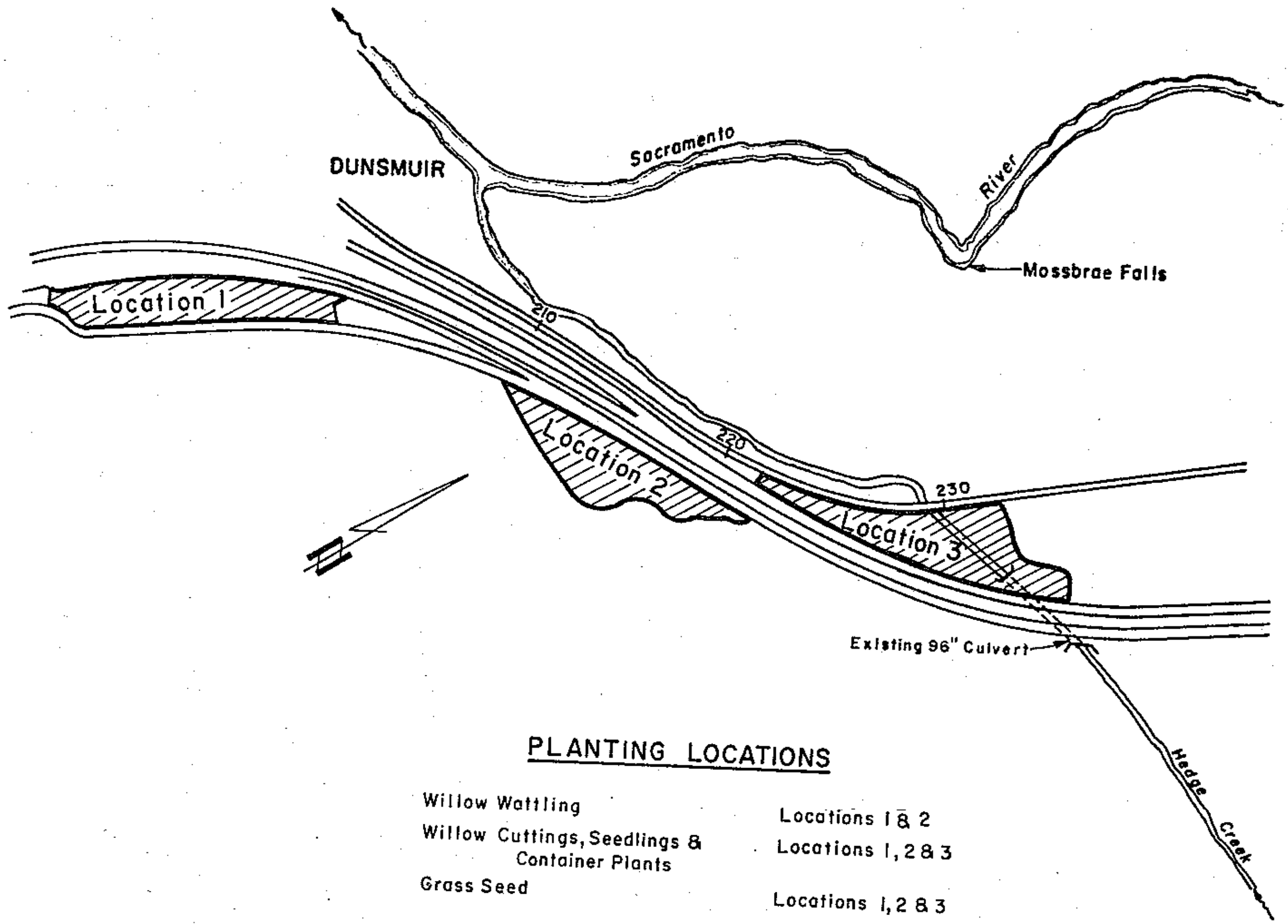

DUNSMUIR
Sacramento
River
Mossbrae Falls
Location 1
Location 2
Location 3
210
220
230
Existing 96" Culvert
Hedge Creek
PLANTING LOCATIONS
Willow Wattling — Locations 1 & 2
Willow Cuttings, Seedlings & Container Plants — Locations 1, 2 & 3
Grass Seed — Locations 1, 2 & 3

FIGURE 13

The slope at Planting Location 2 (Figure 13) was constructed in March 1975. Willow wattling on this slope was started in mid-May 1975. On May 28, 1975, a review of the wattling was made. About 30 percent of the wattling on this slope had been installed. About half the willows were cut and bundled in the Redding area and transported about 50 miles to the job site. The bundles appeared to be drying prior to installation. The size of the bundles was approximately 3-5 inches in diameter. These small bundles were placed in trenches that were too deep and covered with about 6 inches of soil (Photos 11 and 12). Burying the bundles in this manner eliminated the structural advantage of the wattling scheme. Therefore, these bundles could not be effective as a mechanical-slope protection.

The Special Provisions (Section 10-1.15) stated that "A maximum of 10 percent of each wattling shall be left exposed......" This was interpreted by the subcontractor to mean that the bundles could be placed at any depth, as long as more than 10 percent was not left exposed.

An important step in the wattling procedure was left out of the Special Provisions. A statement that "bundles shall be laid in trenches dug to approximately one-half the diameter of the bundles" would have eliminated the complete burying of the bundles.

On June 3, 1975, wattling was in progress below the bench at Planting Location 2. The operation had improved. The subcontractor made arrangements with the Siskiyou County Youth Opportunity Center to provide the additional wattling bundles. These bundles, cut from a State right of way area near Mount Shasta a few miles from the jobsite, were tied and then stored in a creek until installed. The maximum

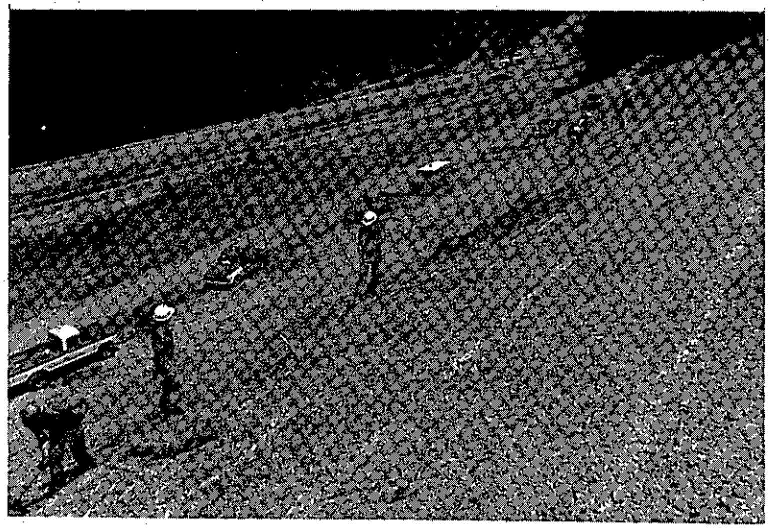


Photo 11
Installation of Willow Wattling

Photo 12
Small Willow Wattling Bundles

time between cutting the willows and installing the bundles was 24 hours. These wattling bundles appeared to be superior to those from the landscape service in Redding. They were larger bundles and tied much better. The bundles from Redding had cost the contractor $2.21 per bundle delivered to the jobsite. The bundles from Mount Shasta cost $1.00 per bundle.

The total cost for installing the willow wattling in the areas above the bench at Planting Location 2, is shown in Table 13.

The willow wattling at Planting Location 2 was completed around mid-August 1975. Areas where bundles had been buried were quite obvious. Inspection of the bundles showed very little evidence of willow survival (see Photos 13 and 14). Installation during the hot summer months was a cause of low survival. The special provisions for new contracts including willow wattling as an erosion control measure, should require installation during late fall or early spring. There should be a soil moisture requirement. It should be noted that many of the willows in the bundles from Redding were wilting before installation.

The total cost for installing the willow wattling in the areas below the bench at Planting Location 2, is shown in Table 14.

Approximately 12,800 lineal feet of willow wattling were installed at Planting Location 1, from mid-August to mid-September 1975.

TABLE 13

COSTS FOR WILLOW WATTLING ON SLOPE ABOVE BENCH

Location 2

Total length of wattling	14,772 lineal ft.
Total cost	$14,965.29
Cost per foot	$1.01
Bid Price	$3.00/foot
Labor:	
Laborers 662 hrs @ $12.48/hr	$8,261.76
Foreman 108 hrs @ $14.85/hr	1,603.80
Pickup Truck 108 hrs @ $2.00/hr.	216.00
1 ton flat bed truck 80 hrs @ $2.75/hr	220.00
Willow Bundles 2110 @ $2.21/bundle	4,663.73

Bundles were 7-9 feet long. Average due to overlapping of ends was 7 feet per bundle.

TABLE 14

COSTS FOR WILLOW WATTLING ON SLOPE BELOW BENCH

Location 2

Total length of wattling	12,914 lineal ft.
Total cost	$6,980
Cost per lineal foot	$0.54
Bid price	$3.00/ft
Labor:	
Laborers 275 hrs @ $13.48/hr	$3,707
Foreman 73 hrs @ $15.85/hr	1,157
Pickup truck 57 hrs @ $2.00/hr	114
1 ton flat bed truck 57 hrs @ $2.75/hr	157
Willow bundles 1,845 @ $1.00/bundle	1,845

Photo 13
Planting Location 2 (July 1975) Above the Bench. Willow Wattling Bundles are Completely Buried.

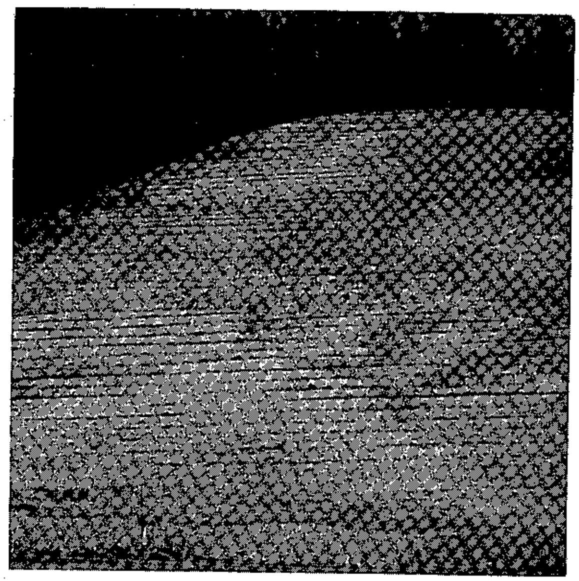


Photo 14
Planting Location 2 (July 1975)

Reviews of the willow wattling installed during the summers of 1976 and 1977 indicated very little willow survival. Although, the willows failed to grow, the contours of wattling minimized the erosion by their structural action, and restricted the formation of rills and gullys. Also the wattling caught the grass seeds, which allowed the seeds to germinate on the slope. By summer 1976, rows of grass were seen along the rows of wattling. The slope was seeded during the fall of 1975. By June 1977, there was an abundance of grass on the slope (Photos 15 and 16).

To determine if willow wattling could grow in this area, in March 1976, District 02 personnel installed three willow wattling bundles at Planting Location 2. The bundles were installed in three different areas of the slope. Each bundle was approximately 9 inches in diameter by 8 feet long. The willows were cut within 5 miles of the slope and placed on the day of cutting (Photo 17). Each bundle had willow growth within 2 months. At 4 months, some willows were over a foot in height (Photo 18). These results show that revegetation with willow wattling is possible. Failure of the "contract wattling" can be attributed to the willows drying before installation and insufficient soil moisture. Willow wattling should be installed in late fall or early spring, when the soil moisture is sufficient.

Approximately 6,900 willow cuttings were planted during the period October 15-26, 1976. Seedlings and container plants were planted in November and December 1976. The contract called for revegetation of 2 cut slopes (Planting Locations 1 and 2) and a fill slope (Planting Location 3). Only 500 Dwarf tan oaks (also called Tanbark oak) were available. In lieu of the other 1,840 tan oaks, acorns

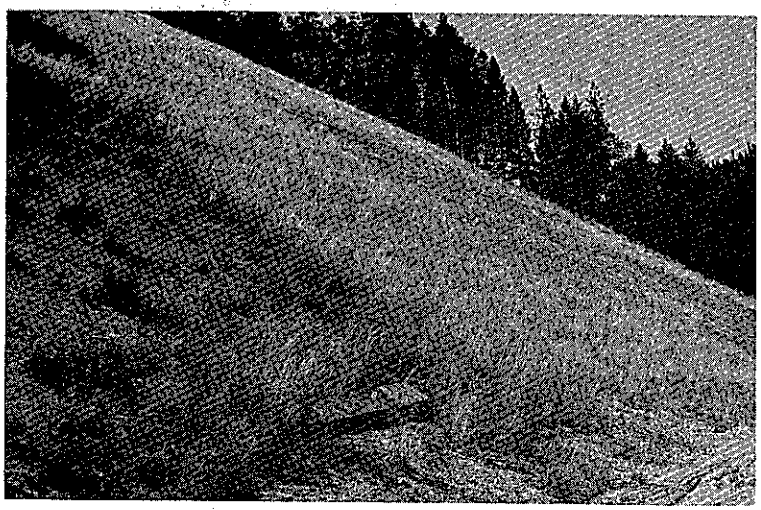


Photo 15
Planting Location 2 - Above the Bench (June 1977)

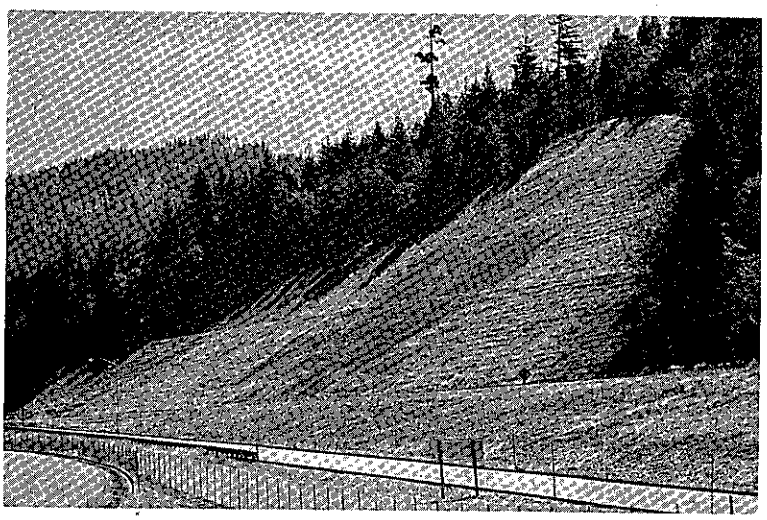


Photo 16
Planting Location 2 - Entire Slope (June 1977)

Photo 17

Willow Wattling Bundle in Trench
Prior to Backfilling (March 1976)

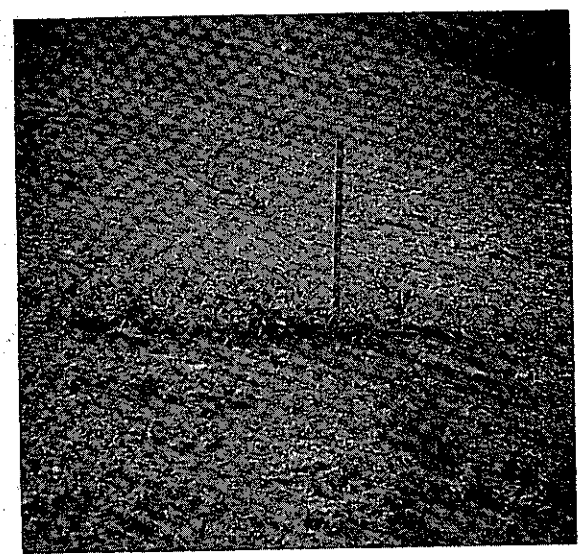


Photo 18

Willow Growth in 4 Months (July 1976)
Notice the Contractor's Bundles are
Completely Buried.

were planted (3,680 holes with 3 acorns and a fertilizer tablet per hole). In addition, some substitutions were made due to the unavailability of some plants (Table 15). All plants and cuttings were stored and watered at the Siskiyou County Youth Opportunity Center at Mount Shasta. In addition, the Youth Center supplied the acorns, Incense cedar, Greenleaf manzanita, willow cuttings and some Bigleaf maple. These were obtained locally.

The soil in most of the planting areas, during the planting, was very dry, even at 8-10 inch depths. As a result, many of the plants were wilting soon after planting.

During the 1975-76 winter, erosion of the earth drainage ditches, along the frontage road and southbound lanes of the new highway, was observed. The eroded material was transported by storm runoff, along the ditches and eventually deposited into Hedge Creek via Culvert 1 (see Figure 12). On February 23, 1976, a settling basin was constructed to alleviate the deposition of sediment in Hedge Creek.

The resident engineer was contemplating paving about 9,000 feet of ditch with asphalt concrete to eliminate the ditch-erosion problem. After learning of these plans, TransLab personnel recommended the use of fiberglass roving with vegetation on some of these ditches, in lieu of asphalt concrete. TransLab personnel had previous experiences with this erosion-control measure(27). After reviewing a TransLab movie that demonstrated the placement and use of fiberglass roving, the resident engineer decided to use fiberglass roving on about 6,500 feet of ditch. The remaining 2,200 feet of ditch were treated with asphalt concrete.

TABLE 15

SEEDLINGS, CONTAINER PLANTS & WILLOW CUTTINGS
PLANTED AT LOCATIONS 1, 2 AND 3

Species, Common Name	Number of Plants: Proposed	Number of Plants: Actually Planted
Abies concolor, white fir	2,340	2,340
Calocendrus decurrens, Incense cedar	3,400	3,400
Pinus ponderosa, Ponderosa pine	3,400	3,400
Acer macrophyllum, Bigleaf maple	1,260	1,040
Pseudotsuga menziesii, Douglas fir	3,400	3,700
Arctostaphylos patula, Greenleaf manzanita	3,400	3,400
Arctostaphylos ura-ursi, Bearberry	3,880	2,680
Ceanothus cordulatus, Mountain whitehorn	3,580	0
Ceanothus intergerrimus, Deer brush	2,320	0
Ceanothus prostratus, Squaw carpet	4,560	1,300
Cornus nuttalii, Western dogwood	2,340	2,360
Lithocarpus densiflora, Dwarf tan oak or Tanbark oak	2,340	500
Symphoricarpos mollis, Snowberry	3,700	2,600
Salix spp., Willow	6,900	6,900
Mahonia aquifolium, Oregon grape	0	1,600
Arctostaphylos media	0	6,000
Cercis occidentalis, Redbud	0	1,100
Ceanothus velutinus, Tobacco Brush	0	100
Quercus kelloggii, California black oak (Acorns)	0	3,680*

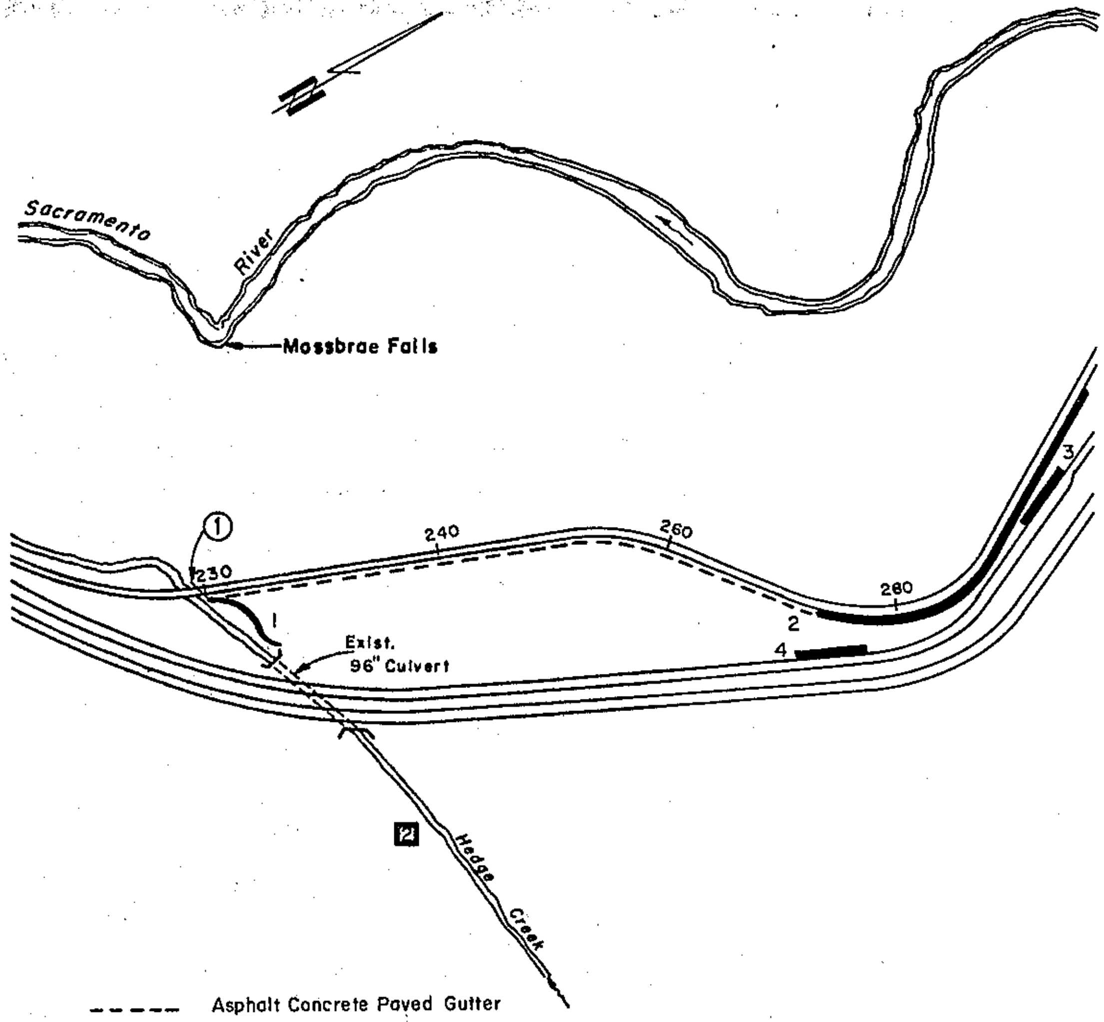
*3,680 holes, 3 acorns per hole.

Fiberglass roving is a material formed from continuous fibers drawn from molten glass. These fibers are gathered into strands to form a single ribbon. This lightly twisted ribbon is known as roving. It is commonly produced in a coiled package to be used in a variety of products and it is readily available commercially.

Before the fiberglass roving is applied, the drainage ditches are reshaped to a relatively smooth and uniform condition. Grass seed and fertilizer are spread over the area to be treated and followed by the fiberglass roving. It was applied using a special nozzle connected to an air compressor. The air propels the fiberglass strands through the nozzle and at the same time separates the strands into individual fibers to form a random mat of continuous fibers. The fiberglass then has the appearance of "angels hair". Finally a tack coat of asphalt emulsion is sprayed uniformly over the roving to bind the fibers together and to adhere the fiberglass mat to the soil. In time the grass will grow through the fiberglass-asphalt mat, resulting in an integrated erosion-control measure.

During the week of October 25, 1976, fiberglass roving was installed for the first time by contract. Four locations were treated with fiberglass roving, a total of 6,500 lineal feet (Figure 14). The average width of the treated ditch was 6 feet. The application rates for the various materials used in this installation were:

Grass Seed	56 pounds per acre
Fertilizer	300 pounds per acre
Fiberglass Roving	0.3 pound per square yard
Asphaltic Emulsion	0.25 gallon per square yard



LOCATION OF FIBERGLASS ROVING AND
ASPHALT CONCRETE DITCH LININGS

FIGURE 14

The cost of installing the fiberglass roving was about $.10 per square foot or about $.60 per lineal foot of ditch. This application and the 2,200 lineal feet of asphalt paved gutter were installed under a contract change order. The cost to install the asphalt paved gutters was about $3.00 per lineal foot.

Photos 19, through 23 show the fiberglass roving installation and some results.

The fiberglass roving with the vegetation (grass) was successful in eliminating most of the ditch erosion at these locations. At Location 1, the fiberglass roving was torn in a few areas and some scouring occurred, but is still considered a success.

As a means of evaluating erosion, a non-treated ditch, located along the frontage road approximately 1/2 mile north of the north end of fiberglass roving Location 2, was used for comparison. This ditch was about 120 feet long. By April 1978, this ditch had eroded an average of 0.9 cubic foot per lineal foot of ditch. The treated ditches did not show any evidence of erosion. Therefore, it is estimated that the fiberglass roving resulted in over 200 CY of decreased ditch erosion.

On April 13, 1978, a vegetative analysis of the treated ditch was made. One square foot representative areas of the fiberglass roving lining were selected and evaluated for vegetative cover. Based on these evaluations, the percentage of grass cover along different segments of these ditches was established (Table 16).

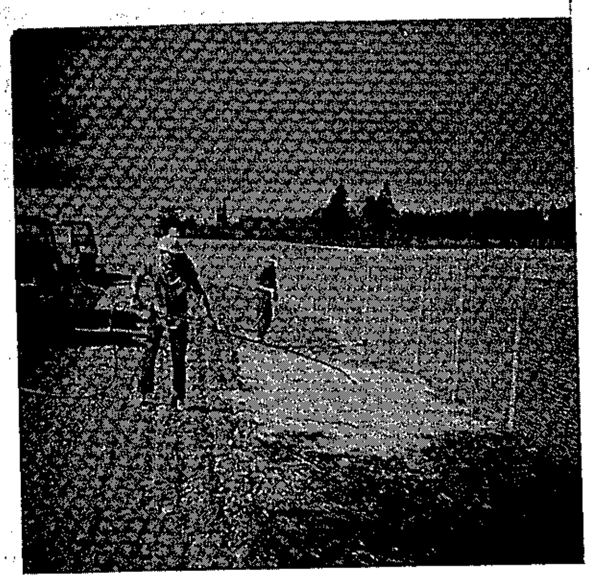


Photo 19

Application of Fiberglass Roving and Asphalt Emulsion at Location 2 (October 1976)

Photo 20

Finished Installation Location 2

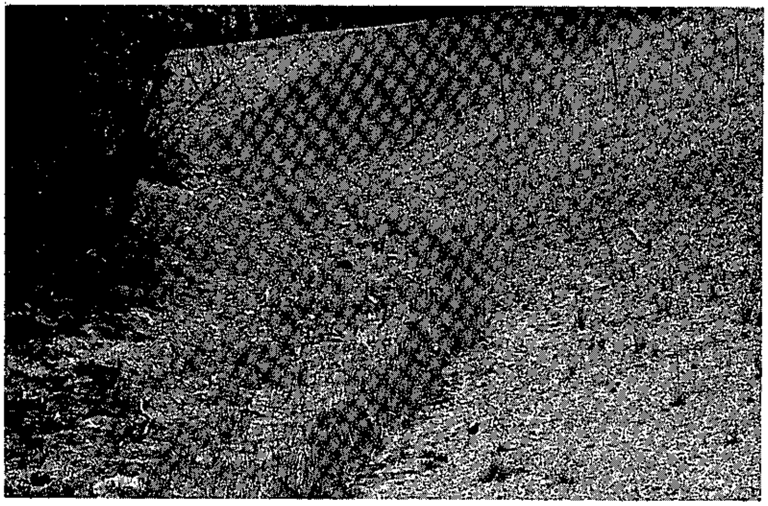


Photo 21
Location 1 (June 1977)

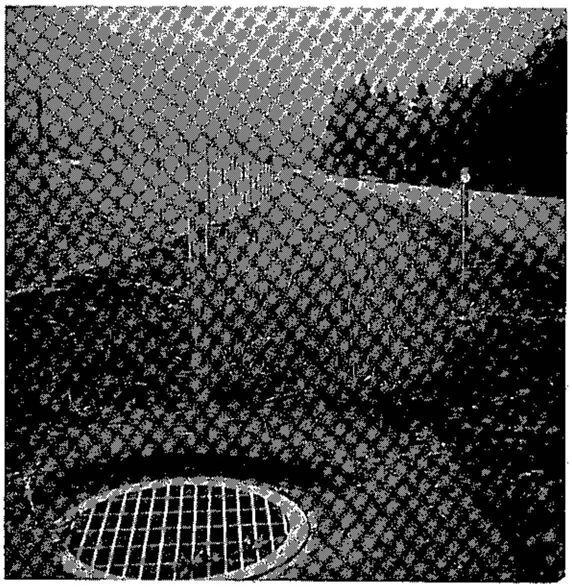


Photo 22
Location 2 - Looking South
(October 1977)

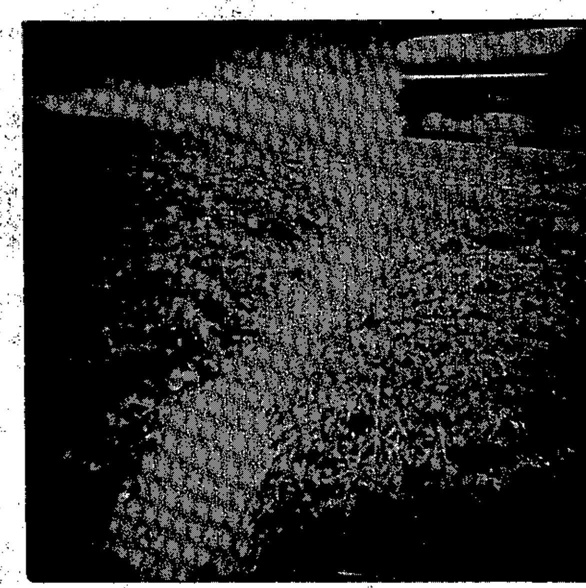


Photo 23

Fiberglass Roving Ditch
(Location 4) During a
Storm in December 1977

TABLE 16

GRASS COVER IN FIBERGLASS ROVING DITCHES

Location	Grade		Station From - To	Ave. Width (ft)	Length (ft)	% Coverage
1	3%		0+00 - 0+30	4	30	0
			0+30 - 1+00	6	70	10
			1+00 - 1+60	6	60	30
			1+60 - 2+00	6	40	10
2	5%	F-2	253+00 - 255+60	7.5	260	25
			255+60 - 256+45	7.5	85	90
			256+45 - 259+00	7	255	10
			259+00 - 262+50	7	350	40
			262+50 - 264+00	6	150	95
			264+00 - 281+50	6.5	1750	5
			281+50 - 284+00	6	250	5
			284+00 - 286+50	6	250	15
			286+50 - 295+00	6	850	50
			295+00 - 301+00	9	600	75
3	5%	A-9	276+00 - 279+00	5	300	40
			279+00 - 281+00	5	200	10
			281+00 - 285+00	5	400	40
4	5%	A-9	246+50 - 249+00	6	250	50
			249+00 - 251+50	6	250	40
			251+50 - 252+00	6	50	20
			252+00 - 254+50		250	40

The construction of the new highway required realignment of about 500 feet of the Hedge Creek channel (Figure 12). The realignment was completed in June 1975. Vegetation was removed and the channel constructed. Riprap was placed along the bottom of the new channel alignment to mitigate against scouring. Photos 24 and 25 show the new channel alignment with the riprap.

Removal of vegetation along a stretch of the stream did result in a water temperature increase. This increase in temperature affected the aquatic ecosystem of that stretch of stream. However, due to the low flows experienced during the drought, the full impact of the warmer water on the aquatic organisms was not realized.

In October 1975, willow cuttings were placed in the realigned channel banks by Caltrans personnel to restore stream-edge vegetation and hasten the recovery of the ecosystem. A few alder and Broadleaf maple cuttings were also placed. The willow cuttings grew very quickly, but the alder and maple cuttings failed to survive. Many alders grew from native seed. Photo 26 shows the willows and native alders approximately 1-1/2 years after planting. During April 1978, 340 willow and 220 alder plants growing in the realigned channel, were counted. The plants ranged from one to 10 feet in height.

The east bank adjacent to the realigned section of Hedge Creek was seeded under contract in October 1975 (Photo 27).

The seeding of the bare areas on the west bank of the realigned section of Hedge Creek by State personnel was made as follows:

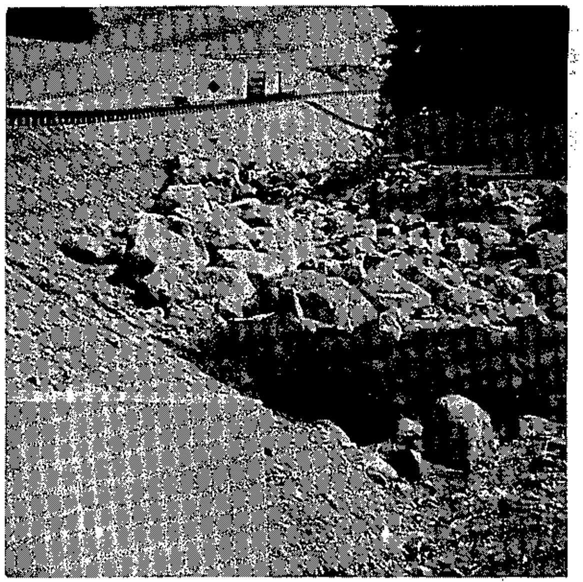


Photo 24

Realigned Channel Looking Downstream From Highway Crossing (June 1975)

Photo 25

Realigned Channel Looking Upstream From Lower End of Alignment (October 1975)

Photo 26
Willow and Native Alder Growth (June 1977)

Photo 27
Seeded Highway Embankment Adjacent to Hedge Creek

a) Seeded with a cyclone seeder, with a mixture of Palestine and Potomac orchardgrasses (October 22, 1975).

b) Hand scattered 1/2 pound of native Redbud seed (Cercis occidentalis) on October 27, 1975.

c) Noted gradual germination of seeded area, but due to frost heaving and subsequent dessication, survival of grasses was low (January 28, 1976).

d) Reseeded with cyclone seeder, with a mixture of Palestine and Potomac orchardgrasses (February 3, 1976).

e) Reseeded with cyclone seeder, using approximately 10 pounds Pubescent wheatgrass, 10 pounds fescue and 5 pounds Lutana vetch (February 18, 1976).

The following observations were made in the Fall of 1977: Scattered clumps of orchardgrass, fescue, and Lutana vetch. Fescue and vetch appear to be reseeding, and spreading slowly. The orchardgrass seems to be struggling. A number of redbuds have grown into 18-24 inch shrubs.

The dominant plant (self seeded) is Sweet clover, which has covered the creek bank between the channel and the right-of-way fence, especially in the reach from Hedge D site upstream to Hedge C site. Another native plant self seeded in large numbers is the Giant mullein.

During the 1975-76 winter, transported materials originating from the project were entering Hedge Creek from a culvert located near the 96-inch culvert. A settling basin was constructed at the inlet to this culvert.

Macroinvertebrate aquatic insect samples were taken in Hedge Creek by TransLab Biologists on July 10, 1975, and June 3 and 4, 1976, for quantitative analyses. Samples were taken above, within, and below the construction project.

During the first sampling on July 10, 1975, the area below the Falls was heavily damaged by silt from the construction. The silt was the result of washing the pavement in the construction area in the evening and not providing for a detention basin prior to the water's entering Hedge Creek. This wash water first entered Hedge Creek just below the Falls and, as a result, the area above the Falls was still in good condition, while below the Falls the stream was essentially void of aquatic insects.

By the second sampling, during June 3 and 4, 1976, it was evident that significant changes were occurring above the Falls as well. Silt from slope erosion along the highway and from the upper watershed during the 1975-76 rainy season, had covered most of the bottom. The silt resulted in a large decrease in the diversity and number of the macroinvertebrate population along this stretch of stream.

Postconstruction Evaluation

The postconstruction-monitoring period, January 1977 through April 1978, was a very unusual period with regard to precipitation. The 1976-77 water year (October through September) was very dry, and the 1977-78 water year was very wet. During January 1, 1977, through September 30, 1977, 20.80 inches of precipitation were recorded at the Mount Shasta Maintenance Station. During October 1, 1977 through April 30, 1978, 46.67 inches were recorded.

A continuous-recording-stream gage (Leupold and Stevens Model 71) was installed at sampling Site D on October 6, 1975. The stream gage height was monitored through May 3, 1978 (Photos 28 and 29).

Flow measurements were obtained over a wide range of stream stages with a Price Current Meter (Table 17). Using the flow measurement data and continuous-stage recordings, monthly discharge data for Hedge Creek were determined (Table 18). Discharge data for the Sacramento River are also shown for comparison.

Due to the drought (1976-77 water year), water-quality sampling during storms was limited to the period December 1977 through January 1978. During this period, water-quality samples and measurements were taken during four storms. Turbidity, specific electrical conductance and chloride were monitored at sampling Sites A, B, C, D and E (Figure 15). Suspended sediment and flow were monitored at Site D. Occasional measurements of pH and temperature were made at Site D. The rainfall for the storms is shown in Table 19. The results of the sampling are shown in Table 20 and 21.

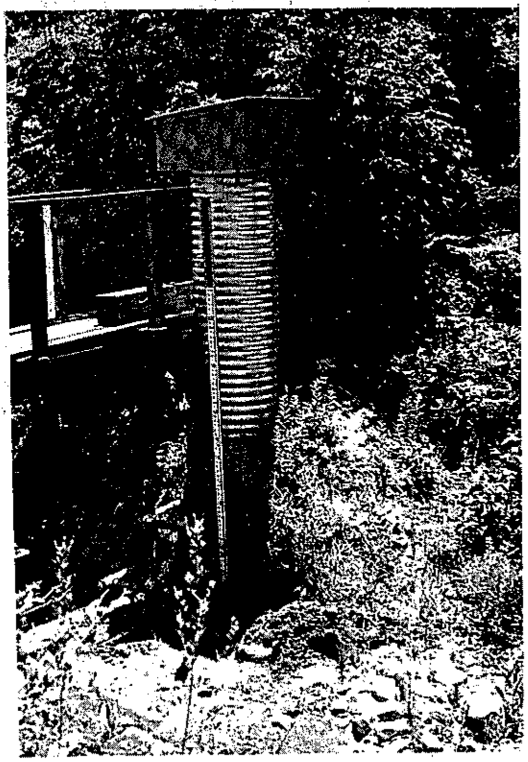


Photo 28
Recording Stream/Gage
(Summer 1977)

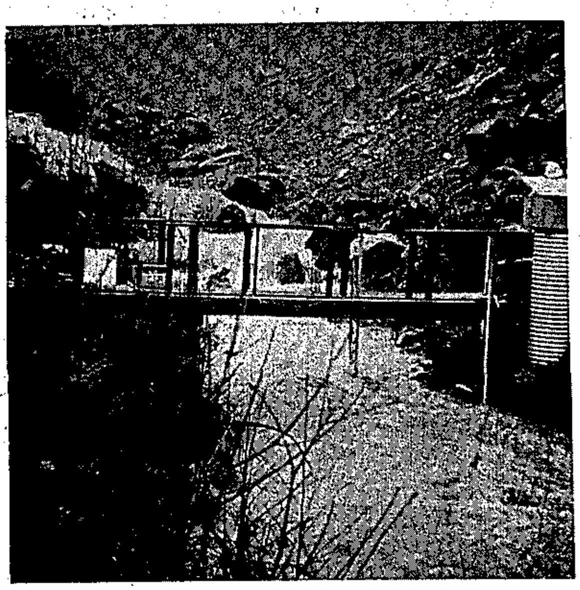


Photo 29
Hedge Creek During High Flow
Stream Gage Height 1.05 Feet
(December 9, 1978)

TABLE 17

FLOW MEASUREMENTS
AT SAMPLING SITE D

Date	Stream Height (ft)	Measured Flow (cfs)
9/28/77	0.54	3.8
	0.48	2.2
	0.36	0.4
12/13/77	0.48	1.2
	0.52	2.0
	0.65	8.8
	0.51	3.8
	0.60	5.3
12/14/77	0.75	10.0
	0.79	14.0
	0.78	10.5
1/4/77	0.78	9.2
1/5/77	0.95	22.8
1/9/77	1.05	31.4

TABLE 18

DISCHARGE SUMMARIES FOR HEDGE CREEK AND THE SACRAMENTO RIVER

		Hedge Creek (Site D)			Sacramento River**		
Month	Total Precip.* (in.)	Min. Discharge (cfs)	Max. Discharge (cfs)	Yield (Ac-ft)	Min. Discharge (cfs)	Max. Discharge (cfs)	Yield (Ac-ft)
Oct. 1975	3.88	0	0.15	2.18	60	151	6,960
Nov. 1975	2.36	0.05	0.25	6.53	100	131	7,090
Dec. 1975	1.74	0.15	0.25	7.43	99	147	6,890
Jan. 1976	0.48	0.15	0.15	6.14	100	105	6,380
Feb. 1976	2.87	0.10	8.75	12.38	54	170	5,750
Mar. 1976	1.22	0.25	0.50	18.02	94	158	7,230
Apr. 1976	3.79	0.25	2.00	21.98	125	703	17,740
May 1976	0.24	0.08	0.25	12.38	130	667	22,780
June 1976	0.43	0	0.20	4.26	58	140	5,680
July 1976	0.28	0	0.10	2.97	52	68	3,630
Aug. 1976	2.55	0.10	0.60	7.72	52	78	3,750
Sept. 1976	0.36	0	0.25	6.24	49	62	3,140
Oct. 1976	0.36	0.03	0.25	6.83	54	120	5,480
Nov. 1976	0.90	0.15	0.25	8.65	47	102	4,150
Dec. 1976	0.73	-	-	-	48	75	4,020
Jan. 1977	1.07	-	-	-	65	84	4,490

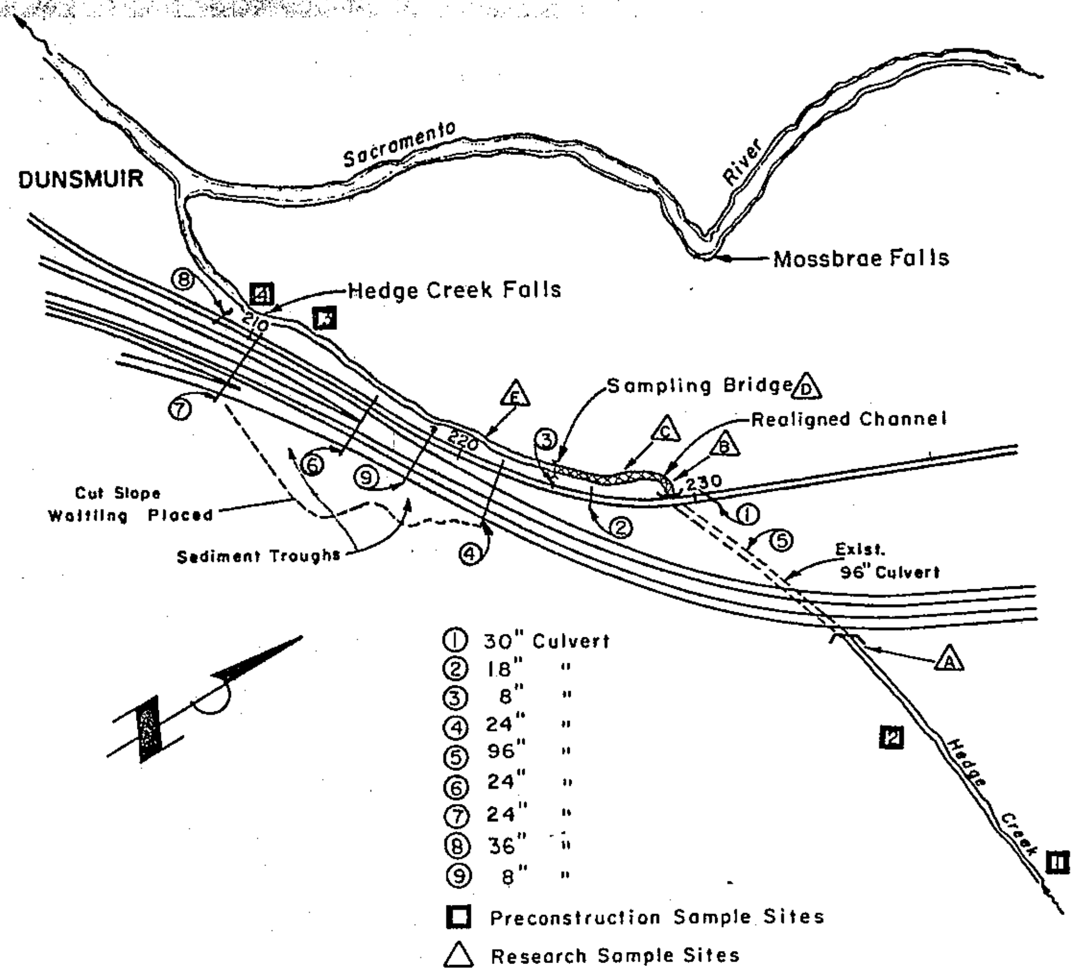
*Recording Precipitation Gage at the Mount Shasta Maintenance Station.
**From "Water Resources Data for California". Monitoring station is located on the Sacramento River, near Mount Shasta, about 5 miles above the confluence of Hedge Creek and the Sacramento River.

TABLE 18 (Cont'd)

DISCHARGE SUMMARIES FOR HEDGE CREEK
AND THE SACRAMENTO RIVER

		Hedge Creek (Site D)			Sacramento River**		
Month	Total Precip.* (in.)	Min. Discharge (cfs)	Max. Discharge (cfs)	Yield (Ac-ft)	Min. Discharge (cfs)	Max. Discharge (cfs)	Yield (Ac-ft)
Feb. 1977	1.84	0.25	0.60	14.99	44	90	4,170
Mar. 1977	1.54	0.25	0.40	16.20	50	76	3,340
Apr. 1977	1.18	0.25	0.30	14.45	56	188	6,490
May 1977	1.71	0.20	0.35	14.45	104	185	8,160
June 1977	0.50	0	0.25	4.75	36	122	4,880
July 1977	0.71	0	0.60	2.51	37	51	2,520
Aug. 1977	0.35	0	0.25	5.45	37	47	2,390
Sept. 1977	3.01	0.25	6.20	16.14	38	143	3,650
Oct. 1977	1.07	0.25	1.50	16.83	100	(mean discharge)***	6,150
Nov. 1977	2.79	0.30	1.70	27.03	96	(mean discharge)***	5,742
Dec. 1977	7.88	0.40	19.0	222.97	351	(mean discharge)***	21,590
Jan. 1978	21.18	-	-	-	825	(mean discharge)***	50,730

*Recording Precipitation Gage at the Mount Shasta Maintenance Station.
**From "Water Resources Data for California". Monitoring Station is located on the Sacramento River, near Mount Shasta, about 5 miles above the confluence of Hedge Creek and the Sacramento River.
***Minimum and Maximum Discharge Data not available.



POSTCONSTRUCTION SAMPLING SITES

FIGURE 15

TABLE 19

RAINFALL DATA FOR SAMPLED STORMS AT SITES A, B, C, D & E

	Date	Rainfall (inches)	
Storm 1	12/11/77	0.63	
	12/12/77	0.38	
	12/13/77	0.66	(Began sampling at 0830 hrs)
	12/14/77	2.33	
Storm 2	1/2/78	0.69	
	1/3/78	0.36	
	1/4/78	1.88	(Began sampling at 1310 hrs)
	1/5/78	0.79	
Storm 3	1/8/78	1.18	
	1/9/78	1.24	(Began sampling at 1040 hrs)
Storm 4	1/11/78	0.76	
	1/12/78	0.15	
	1/13/78	0.72	
	1/14/78	2.94	
	1/15/78	2.06	
	1/16/78	2.60	(Took 1 sample at 1200 hrs)
	1/17/78	0.02	
	1/18/78	0.46	(Began sampling at 1500 hrs)
	1/19/78	0.20	

TABLE 20

TURBIDITY DURING STORM PERIODS

Date	Time (hrs)	Flow* (cfs)	Turbidity (NTU) at Sites A	B	C	D	E	Suspended Sediment (ppm)
12/13/77	0830	1.2	-	99	-	86	-	81
	1015	2.0	3.4	380	270	320	-	593
	1345	8.8	-	-	-	1225	-	2919
	1615	3.8	20	111	120	99	-	143
	1740	5.3	-	-	-	555	-	1336
12/14/77	0800	10.0	-	-	-	150	-	576
	0900	14.0	-	-	-	420	-	1510
	1000	14.0	111	111	230	280	-	547
	1120	10.5	-	-	-	220	-	686
1/4/78	1310	13.9	12	17	29	48	36	224
	1400	15.8	19	22	28	32	50	611
1/5/78	1100	20.5	-	-	-	15	-	121
1/9/78	1040	31.4	96	108	96	95	102	642
1/16/78	1200	60**	-	-	-	-	102	608
1/18/78	1500	31.0	26	24	21	28	24	67
1/19/78	0800	30.1	4	3.8	3.6	4.2	4.7	14
	1300	19.1	3.7	3.2	3.4	3.4	3.6	12

*Flow taken at Site D.

**This value is an estimate. Due to high precipitation and subsequent large flows on January 14, 15 and 16, 1978, the channel bottom had eroded. The stage gage reading was 1.1, but the depth of the water in the center was about 3 feet. The velocity was to large to take flow measurements. This estimate is probably a very low estimate.

TABLE 21

WATER CHEMISTRY DURING STORM PERIODS

Date	Time (hrs)	Flow* (cfs)	Chloride (mg/l)					Specific Electrical Conductance mmhos/cm @ 25°C				
			A	B	C	D	E	A	B	C	D	E
12/13/77	0830	1.2	-	-	-	-	-	-	-	-	42	-
	1015	2.0	-	-	-	-	-	-	-	-	34	-
	1345	8.8									28	-
	1615	3.8									52	-
1/4/78	1310	13.9	0.91	0.46	0.35	0.25	0.25	63	62	52	54	50
	1400	15.8	0.51	0.30	0.25	0.20	0.15	64	57	47	54	46
1/5/78	1100	20.5				0.71					55	
1/9/78	1040	31.4	0.05	0.10	0.10	0.51	0.20	47	47	48	50	48
1/16/78	1200	60**				0.10					38	
1/18/78	1500	31.0									32	32
1/19/78	0800	30.1									36	35
	1300	19.1									35	34

*Flow taken at Site D.

**See footnote on Table 20.

Turbidity along the realigned channel was usually higher than at the control Site A, located upstream from the construction. The data indicate that there is an increase in turbidity due to the construction. Preconstruction turbidity measurements indicated no noticeable difference between sites located above and below the proposed construction zone.

The Sacramento River Basin Water Quality Objectives(22) require that where natural turbidity is between 0 and 50, 50 and 100, and greater than 100 turbidity units, the increase shall not exceed 20%, 10 turbidity units, and 10%, respectively. The data show that this standard was exceeded on several occasions.

Concentrations of suspended sediment usually increased with increased turbidities.

The limited chloride analyses showed very low concentrations, less than 1 mg/l, with very little change between sites. The low chloride concentrations reflect the fact that deicing salts have not been applied to the section of roadway near Hedge Creek since the 1975-76 winter. The "Water Quality Criteria"(21), indicates that a concentration of 400 mg/l chloride is harmful to trout.

Specific electrical conductance (conductivity) was low, with very little change between sites. The Sacramento River Basin Water Quality Objectives limit the conductivity to 230 micromhos/cm (50 percentile).

The pH measurements indicated very little change during and between storms. The pH averaged around 8.2 indicating a basic or alkaline water.

TABLE 22

CHEMICAL PARAMETERS (POSTCONSTRUCTION)

Parameter		Temperature		Turbidity	Total Hardness	Sulfate	Nitrate	Chloride	Alkalinity	pH	Dissolved Oxygen		Specific Conductance
Test Method		Calif. 734 11/1/76		Calif. 731 11/1/76	Calif. 745A 10/1/73	Calif. 745A 10/1/73	**	Calif. 745A 10/1/73	Calif. 745A 10/1/73	Calif. 747A 4/1/74	*		Calif. 732 11/1/76
Units		°C		NTU	mg/l	mg/l	mg/l	mg/l	mg/l	pH	mg/l		mmhos/cm @ 25°C
Date	Site	Air	H_2O									Sat.	
2/24/78	1	8	4	0.74	30.5	Trace	0.1	0	29.4	7.3	12.4	11.2	58
	2	8	4	0.79	35.6	Trace	0.1	0.20	30.5	7.35	12.7	11.2	61
	3	7	6	0.94	38.4	Trace	0.15	0.56	31.4	7.35	12.5	11.3	59
	4	7	5	0.92	38.4	Trace	0.20	0.56	31.8	7.35	12.6	11.6	64
3/15/78	1	6	4	0.80	27.8	Trace	0.1	0	26.4	7.0	12.9	11.8	65
	2	4	4	0.80	31.1	Trace	0.1	0	27.3	7.1	12.9	11.8	66
	3	12	6	0.80	31.1	Trace	0.1	0.46	27.0	7.2	12.5	11.3	65
	4	11	6	0.80	31.1	Trace	0.1	0.46	28.7	7.3	12.5	11.3	68
3/21/78	3	8	6	1.3	33.1	Trace	0.2	0.56	30.8	7.1	11.5	11.3	74
	4	8	6	1.3	33.1	Trace	0.2	0.56	31.2	7.3	11.6	11.3	77
3/28/78	1	16	6	0.9	31.9	0	0.2	0.20	30.9	7.0	11.3	10.5	71
	2	16	6	1.1	32.7	Trace	0.2	0.20	30.9	7.2	11.3	10.8	74
	3	18	7	1.2	32.3	Trace	0.2	0.36	31.3	7.2	11.1	10.5	81
	4	14	7.5	1.2	33.9	Trace	0.1	1.07	32.7	7.3	10.9	10.5	86
4/18/78	1	5	5	0.9	30.7	Trace	0.1	0	31.4	7.2	11.6	11.1	66
	2	8	5	0.9	30.7	Trace	0.1	0.10	31.0	7.2	11.6	10.5	68
	3	8	5	0.9	30.7	Trace	0.1	0.10	31.7	7.4	11.6	10.9	67
	4	8	6	1.0	30.7	Trace	0.1	0.36	32.1	7.4	11.0	11.3	72
4/25/78	1	15	6	0.6	29.7	1.6	0.1	0.10	31.0	7.15	10.9	11.3	68
	2	15	6	0.6	32.3	0.8	0.1	0.31	31.2	7.2	10.9	11.3	71
	3	16	6.5	0.8	32.7	Trace	0.1	0.46	31.6	7.4	10.7	11.2	70
	4	15	6.5	0.9	32.9	Trace	0.1	0.56	32.3	7.5	10.9	11.2	70

*Analyzed with a Martex Model DOA

**Analyzed with DR-EL Portable Direct-Reading Engineers Water Test Laboratory Kit, Hach Chemical Company.

TABLE 23

SUSPENDED SEDIMENT TRANSPORT (HEDGE CREEK)

Date	Conc. mg/l	Q_s, tons/day
9/28/77	462	0.62
	1277	5.17
	1426	9.63
12/13/77	81	0.26
	593	3.20
	2919	69.36
	143	1.47
	1336	19.12
12/14/77	576	15.55
	1510	57.08
	547	15.51
	686	19.45
1/4/78	224	8.41
	611	26.07
1/5/78	121	6.70
1/9/78	642	54.43
	474	40.19

During February, March and April 1978, water was sampled at the 4 preconstruction sampling sites. The samples were analyzed for the parameters monitored during preconstruction. Table 22 shows the 1978 data. Comparison of these data with data collected in 1973 and 1974, indicates no significant changes in these parameters except for chloride, which decreased in concentration because the use of deicing salts was temporarily terminated. The "Water Quality Criteria" and "Basin Objectives" were not exceeded. Table 2 shows the preconstruction data and also lists the water quality criteria and basin objectives.

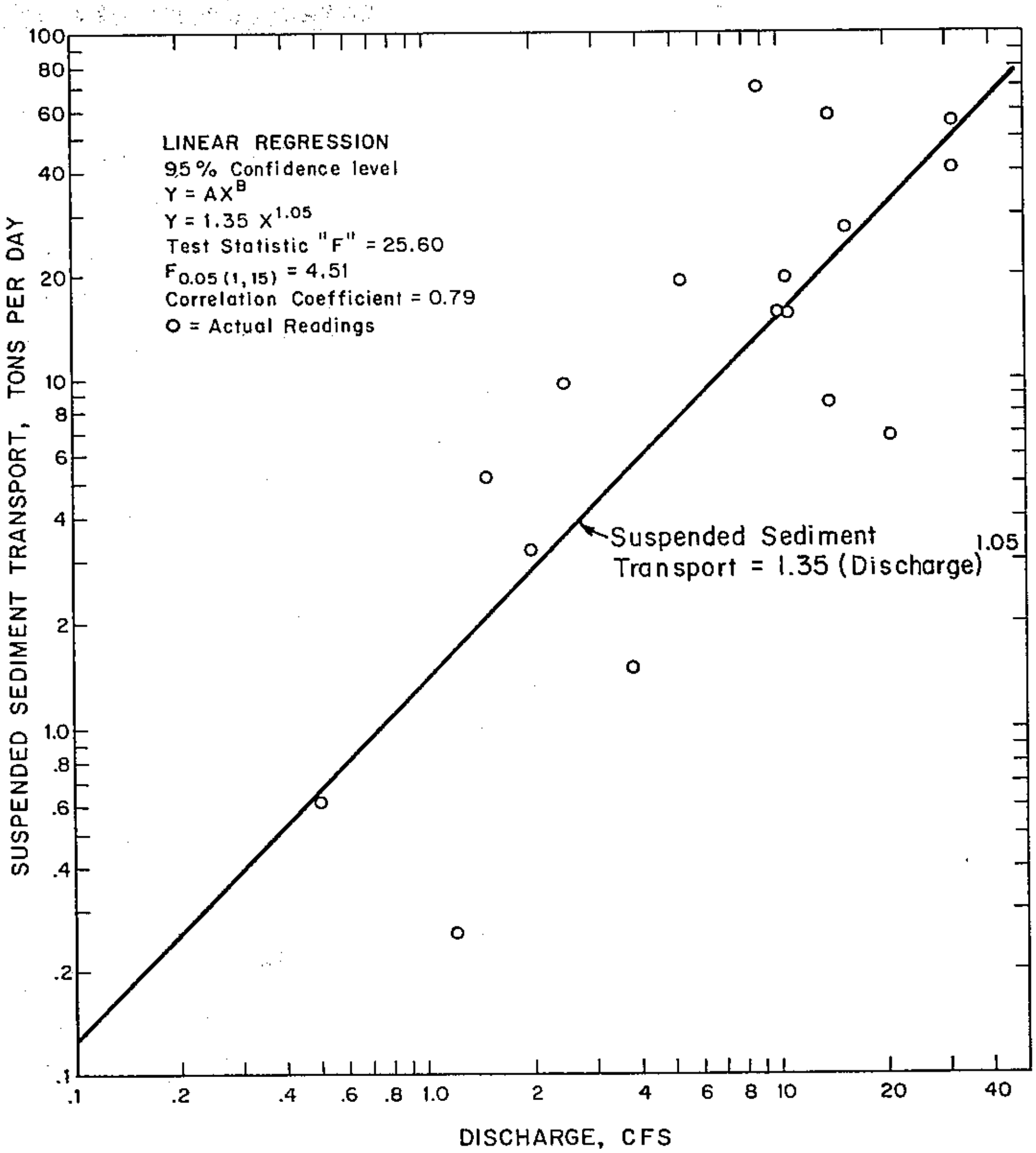
Suspended sediment samples and flow were taken at Site D on the following dates and laboratory analyses yielded the concentrations shown in Table 23. Use of the instantaneous suspended sediment formula gives the suspended sediment load(28).

$$Q_s = Q_w CK$$

°here:

Q_s = suspended sediment load, tons/day
Q_w = flow, cfs
C = suspended sediment conc., mg/l
K = 0.0027

These data combined with stream discharge information are plotted to make a sediment rating curve as shown on Figure 16.



SUSPENDED SEDIMENT RATING CURVE

FIGURE 16

A linear-regression analysis using the CURVEFIT computer program results in the following equation:

$$Y = 1.35\ X^{1.05}$$

Where:

Y = suspended sediment load, tons/day

X = streamflow, cfs

The correlation is 0.79 which represents a fair curve fit. Additional data are needed to determine the relationship more accurately.

Using the mean-daily discharges and the sediment-rating curve results, the following estimates of monthly-sediment discharges were determined.

TABLE 24

MONTHLY SEDIMENT LOAD (TONS)

Feb. 1977	March	April	May	June	July
16.2	20.2	19.5	19.4	6.6	1.8

Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 1978
3.0	20.4	20.9	31.1	166.9	391.3

The total suspended-sediment discharge for the period shown in Table 24 is 717.3 tons. About 558.2 tons (78%) of the total suspended sediment were discharged between December 1, 1977 and January 16, 1978.

Discharge and suspended-sediment transport beyond January 16, 1978 were not determined. During the storm of January 14-16, 1978, the channel had scoured and the stage-discharge and sediment-rating curves are not applicable due to the new channel configuration.

Personnel from the District 02 Physical Environmental Studies Unit assisted on the research project by collecting and testing water samples during storm periods. Since the District 02 office is located in Redding, about an hours' drive from Hedge Creek, there was a problem in arriving at the site in time to collect suspended-sediment samples during peak runoff conditions. Therefore, in September, 1976, a stationary-suspended-sediment sampler was installed to collect samples at various levels of high flow (Photos 30 and 31). The sampler consisted of an aluminum post that was secured in the stream bed and attached to the sampling bridge. Another aluminum member was fitted with sampling bottles. Each bottle is equipped with two copper tubes; one for sample intake and the other for air exhaust.

This type of sampler may perform well in larger watersheds, where the rise and fall of stream stage is slow. The Hedge Creek watershed is very small (2.6 sq. miles) and has a very short response time to peak flow. Therefore, the rise and fall of Hedge Creek (stage) is very rapid during storms. During intermittent rainstorms, the creek may rise and fall several times during a short time before a bottle fills. This made it impossible to correlate stage height with the stationary-suspended-sediment samples.

Photo 30

Stationary Suspended Sediment Sampler (October 1976)

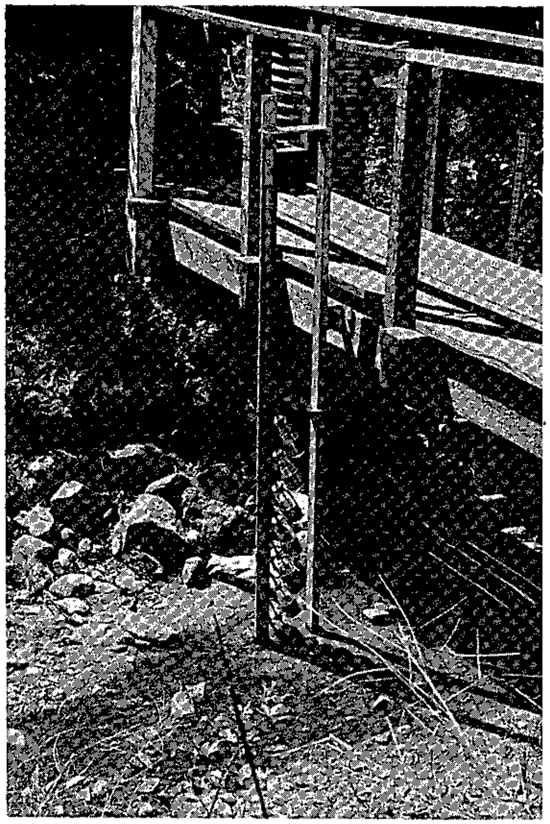


Photo 31

Stationary Suspended Sediment Sampler on Footbridge Looking Upstream

Erosion of the large cut slope (Planting Area 2) was monitored from May 16, 1977, through May 4, 1978, using sediment-collection troughs(29). The sediment-collection troughs were installed in the approximate location of the preconstruction troughs. During the monitoring period, 56.46 inches of precipitation were recorded. Collected sediment was equivalent to 5.52 and 1.52 tons per acre at Sites 1 and 2, respectively. These figures are compared to preconstruction data of 87 inches of precipitation and sediment of 10 and 21 tons per acre at Site 1 and 2 respectively. Table 25 and Figures 17 and 18 show a reduction in rate of erosion from this slope, especially at Site 2.

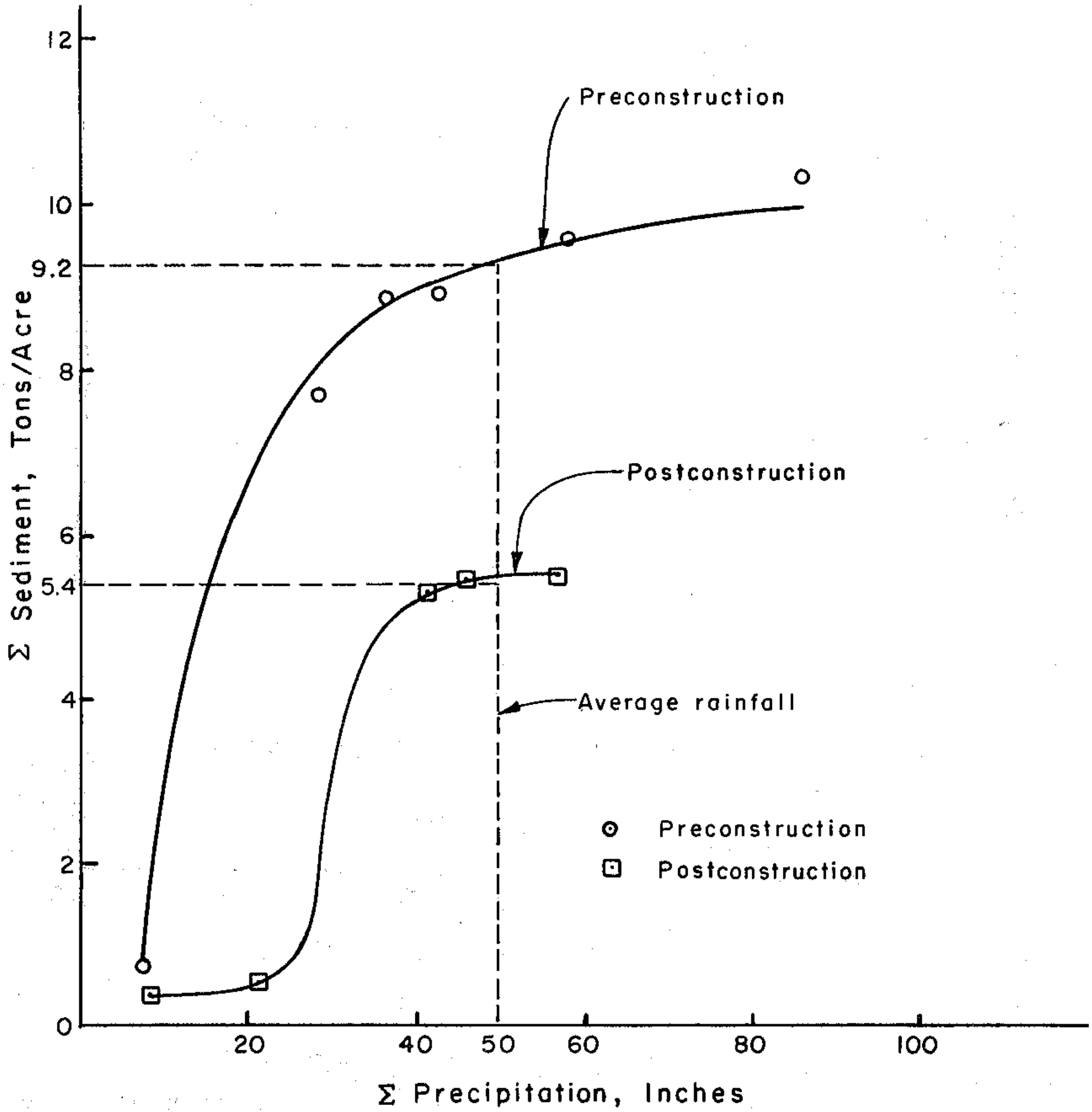
The erosion for a normal rainfall of 50 inches during the postconstruction period was much less than during preconstruction. The reduction in erosion can be attributed to the established vegetation on the slope and the mechanical action of the willow wattling.

TABLE 25

EROSION RATE, TONS/ACRE

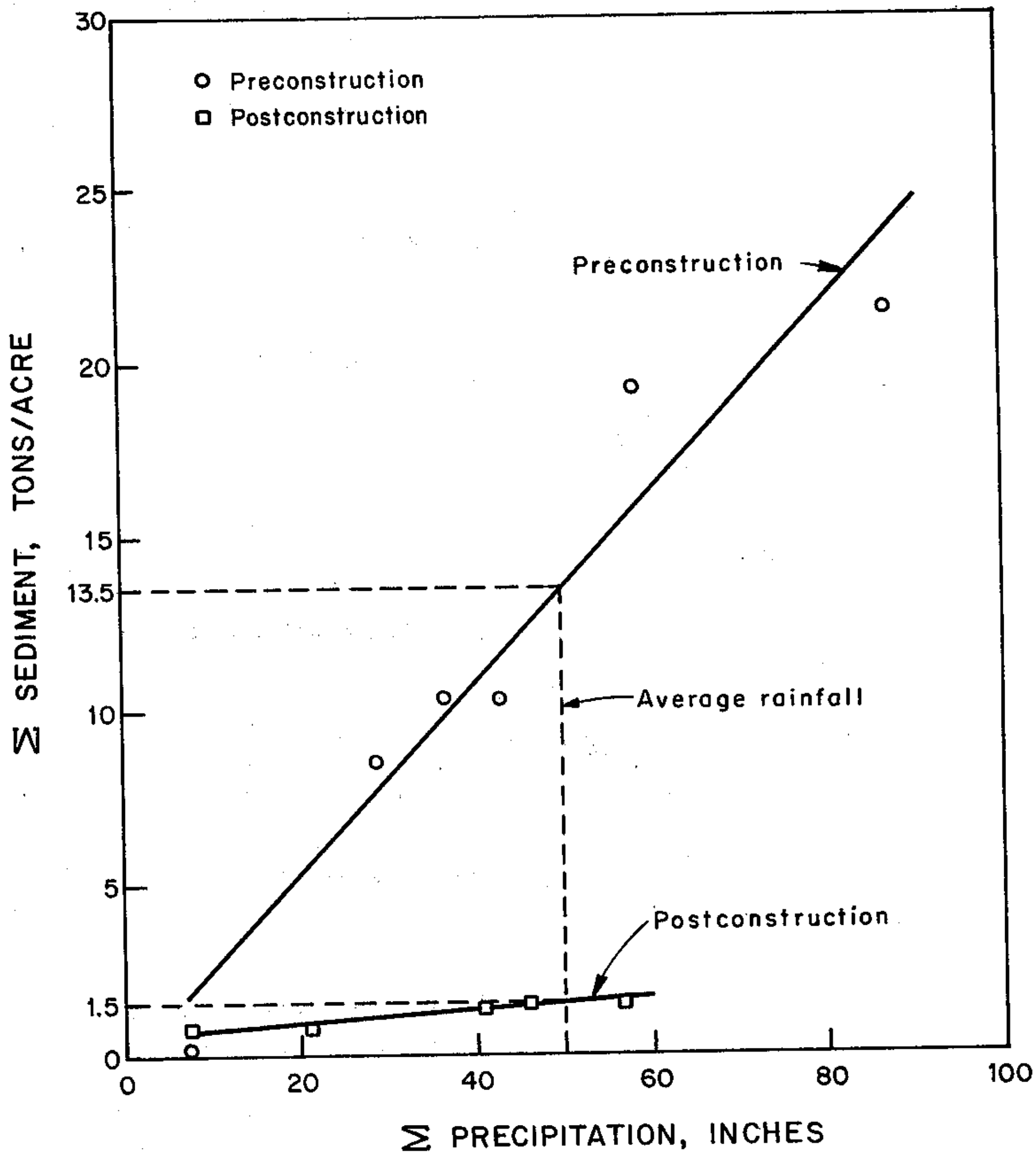
	Preconstruction	Postconstruction
Site 1	9.2	5.4
Site 2	13.5	1.5

Sheet and rill erosion of the fill slope located near the realigned section of Hedge Creek, between the freeway and frontage road, was evident. The fill slope between the frontage road and Hedge Creek also eroded. One section, located on the east bank just upstream from sampling Site D (sampling bridge), was severely eroded (Photos 32 and 33). The section, approximately 115 feet



SEDIMENT ACCUMULATION CURVE
PRECONSTRUCTION AND POSTCONSTRUCTION PERIODS
SITE I (NORTH TROUGH)

FIGURE 17



SEDIMENT ACCUMULATION CURVE FOR
PRECONSTRUCTION AND POSTCONSTRUCTION PERIODS
SITE 2 (SOUTH TROUGH)

FIGURE 18

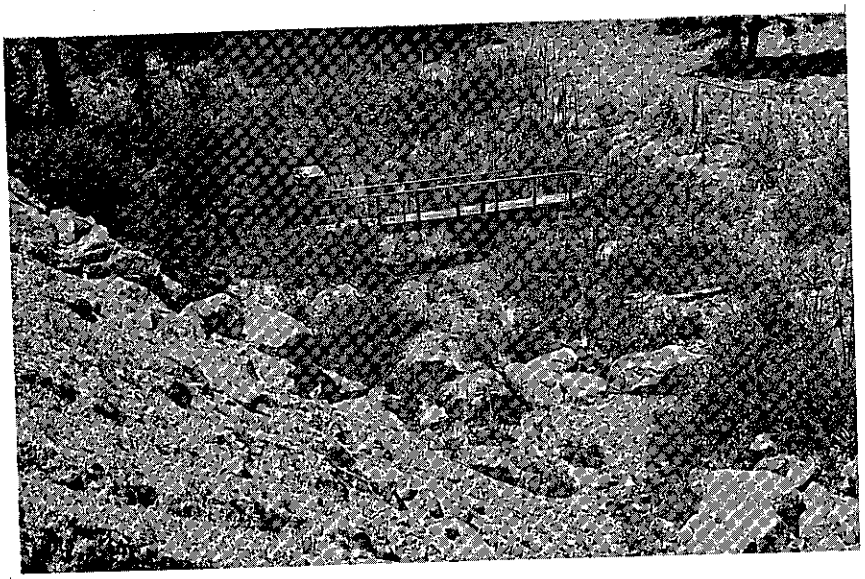


Photo 32

Gully Erosion of East Bank of Hedge Creek
Below Frontage Road (February 1978)

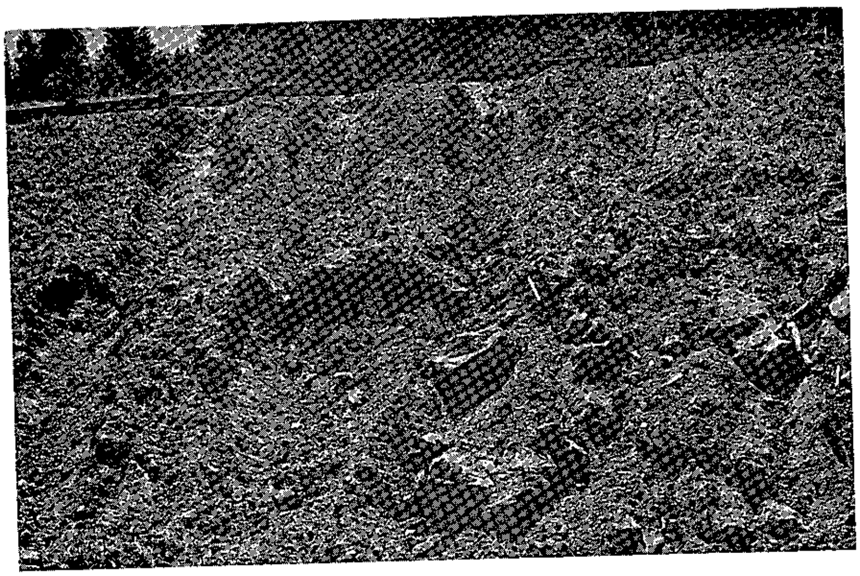


Photo 33

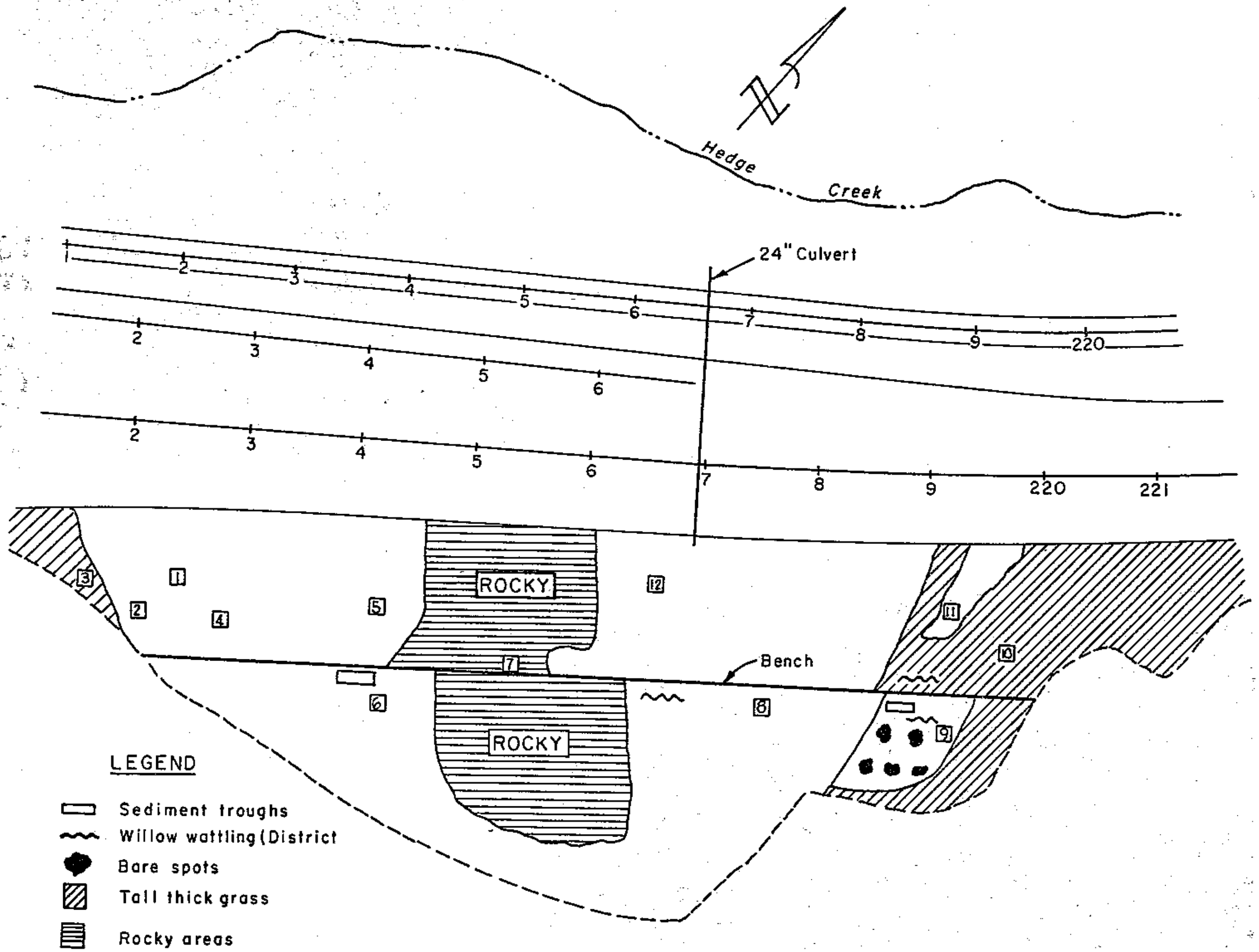
Toe of Slope Near Realigned Hedge Creek

in length, had 16 large gullies, some which had a depth of 2 feet and widths of 7 feet in some parts. The gullies were measured on April 14, 1978. The gully erosion in this section of bank equalled approximately 44 cubic yards. Most of the sediment had entered Hedge Creek, which runs along the toe of the fill.

On May 4, 1978, a field analysis of survival, cover, and growth of woody vegetation and grass at Planting Location 2 was made. Twelve 10-foot square plots were transected for vegetation growth and cover (Figure 19).

Survival of the willow wattling installed under contract was very poor, although some growth was noticed on the most southern lower portion of the slope. The three willow wattling bundles installed by District 02 personnel were growing vigorously. Survival of willow cuttings, container plants and seedlings was fair (Photos 34 and 35), with an average of 6.4 plants per 10' x 10' plot. Grass survival was very good, which can be attributed to the structural effect of the wattling in allowing a place for seed to germinate. Very little vegetation was noticed when grass cover approached 75%, indicating that a dense growth of grass leaves little moisture, nutrients, etc., for plant survival. The vegetation-survival counts and grass cover for the plots are shown in Table 26.

Nine culverts were installed in the vicinity of Hedge Creek (Figure 20). Scouring at outlets was reduced at Culverts 1 through 5 by utilizing different techniques. Culverts 1, 3 and 4 were riprapped and Culvert 2 was grouted (Photos 36 and 37). An energy dissipator was constructed at Culvert 5 (Photo 38).



SITES FOR VEGETATION ANALYSIS
(PLANTING LOCATION 2)

FIGURE 19

Photo 34

Willow Cutting (June 1977)
Planted October 1976

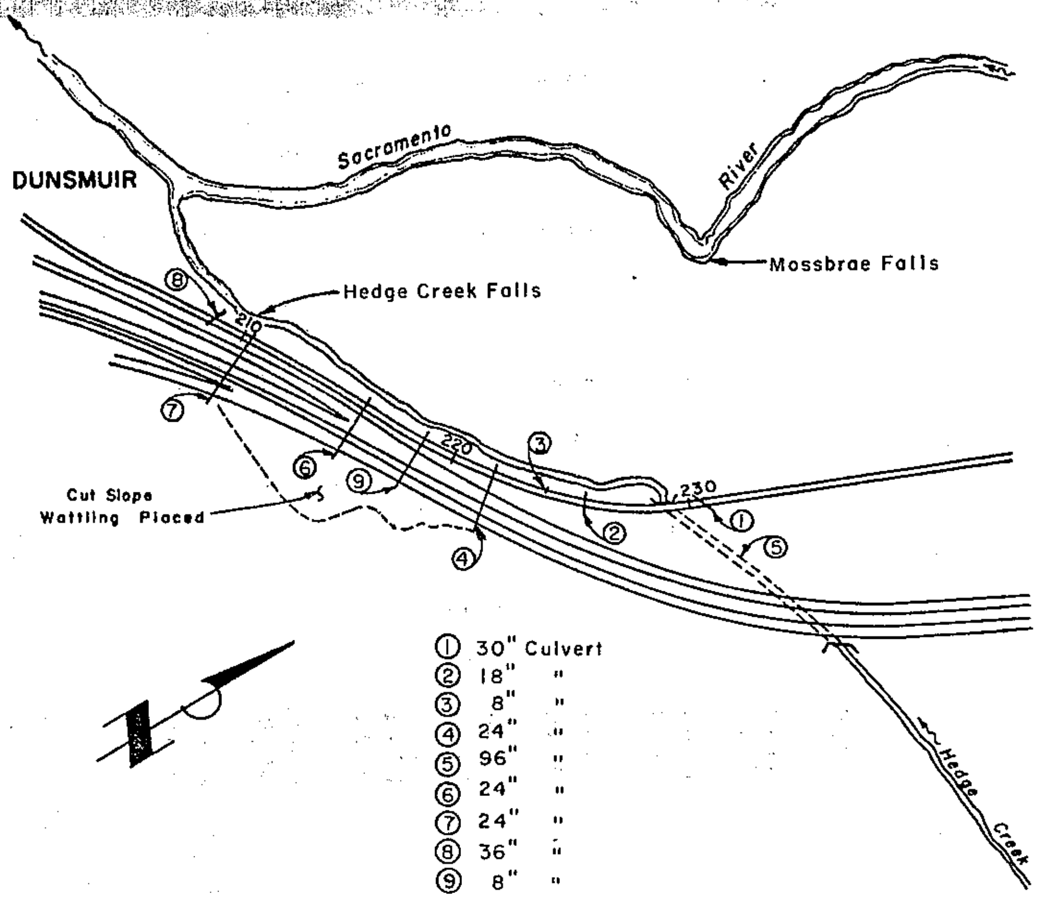
Photo 35

Ponderosa Pine (June 1977)
Planted October 1976

TABLE 26

VEGETATION ANALYSIS AT PLANTING LOCATION 2

		Site Location Number												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Ceanothus spp.	Live	2				3		1	3					9
	Dead													0
Arctostaphylos spp.	Live	4	3			1		2	2	2			3	17
	Dead							1						1
Salix spp./wattlings	Live	4	3		1		1					1		10
	Dead													0
Salix spp./cuttings	Live	2	3	1	1		2	5	2			4		20
	Dead				1		4	1	1		2			9
Pseudotsuga menziesii	Live	1	2		3	3	2		1			2		14
	Dead	2					5		1		1			9
Calocendrus decurrens	Live				1				1					2
	Dead							1	1				1	3
Pinus ponderosa	Live					2		3		1				6
	Dead									1				1
Lithocarpus densiflora	Live						1		1	4				6
	Dead													0
Acer macrophyllum	Live						1			1				2
	Dead													0
Total	Live	13	11	1	6	9	7	11	10	8	0	7	3	86
	Dead	2	0	0	1	0	9	3	3	1	3	0	1	23
Percent Grass Cover	Live	55	55	75	50	50	55	5	65	10	75	50	60	



CULVERT LOCATIONS ALONG HEDGE CREEK

FIGURE 20

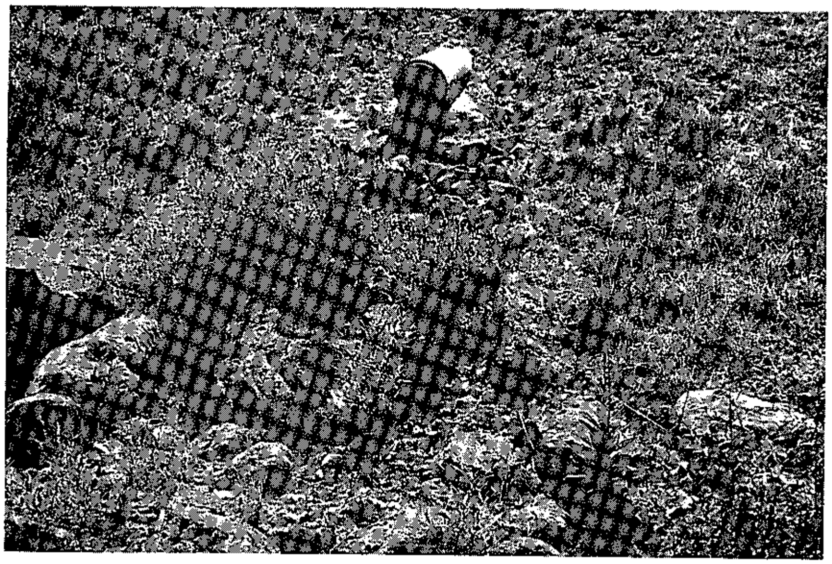


Photo 36

Culvert 2-Grout and Rocks in Place to Prevent Scouring Below the Culvert

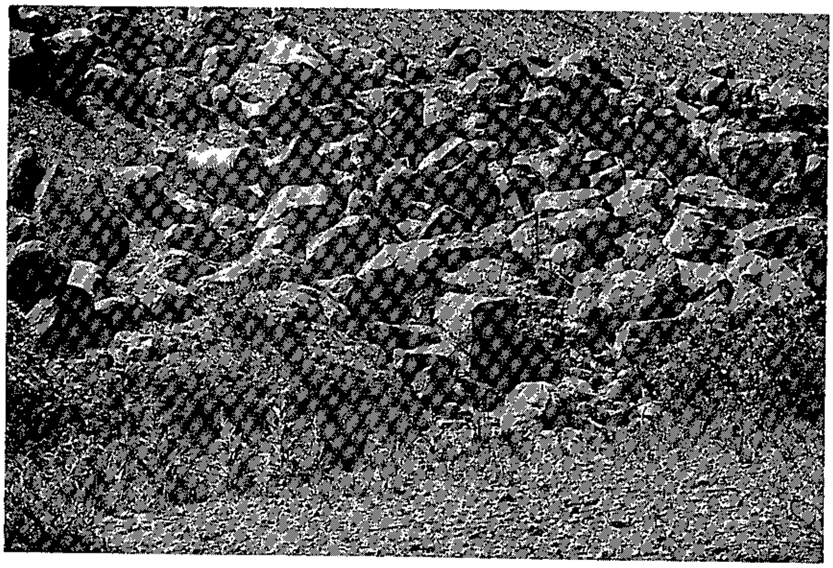


Photo 37

Culvert 4-Riprap

Scouring below Culverts 6, 7, 8 and 9 was evident. A tremendous volume of material was scoured from around these culvert outlets. Erosion of Culverts 6, 7, 8 and 9 resulted in 8 cy, 34 cy, 22 cy and 2 cy, respectively (Photos 39 through 41). These figures represent the scour in the vicinity of the culvert outlets. Erosion of the area from the culvert outlet to the creek was evident, but was not measured.

To determine the effects of the construction project on stream biota, Hedge Creek was sampled for aquatic macroinvertebrates during the construction- and postconstruction-monitoring periods. Samples were collected during July 1975 (sample period I); June 1976 (sample period II); March 1977 (sample period III); November 1977 (sample period IV); January 1978 (sample period V); and April 1978 (sample period VI). All samples were taken at sites as shown in Figure 21, except sample period I and sample period V. During sample period I, site 8 was not sampled. It was added to the sampling schedule during sample period II. During sample period V (January 1978), the water level in Hedge Creek was so high that only site 2 could be sampled (all other sites were unreachable).

During all sampling periods, 65 species were collected. A list of the species captured including date and sample period is given in Table 27. The ten most abundant species captured are shown in Table 28. Sample periods IV and V are not included in the table since few macroinvertebrates were collected during these periods due to water levels being either too low or too high.

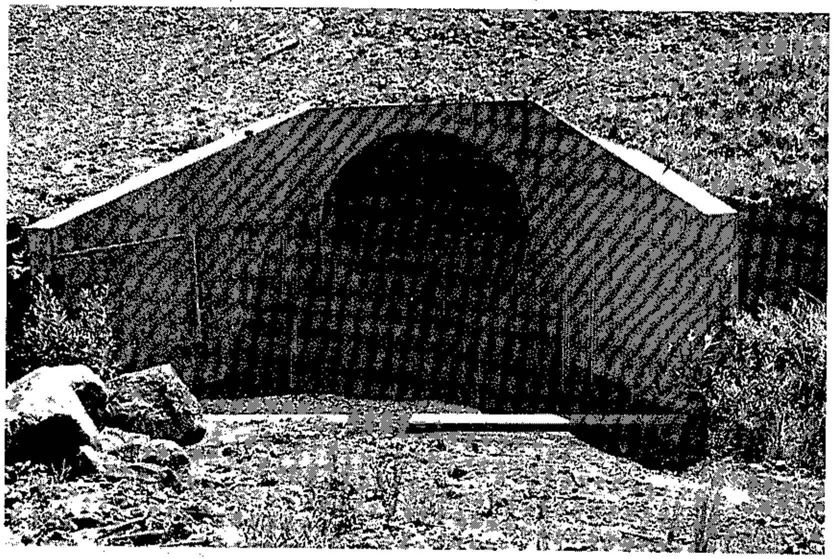


Photo 38

Summer 1977
Energy Dissipator, Culvert 5

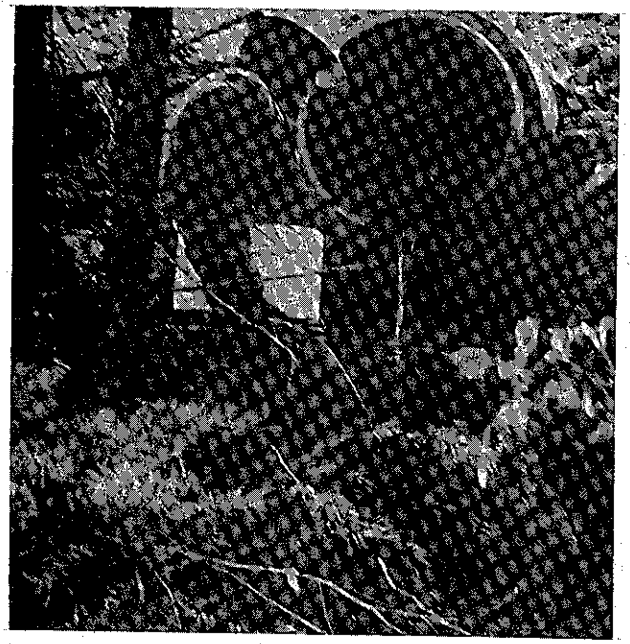


Photo 39

April 14, 1978
Culvert 6, Scour Hole

Photo 40

April 14, 1978
Scour Hole Below Culvert 7.
The Hole was 6 Feet Deep and
10 Feet Wide at Some Locations

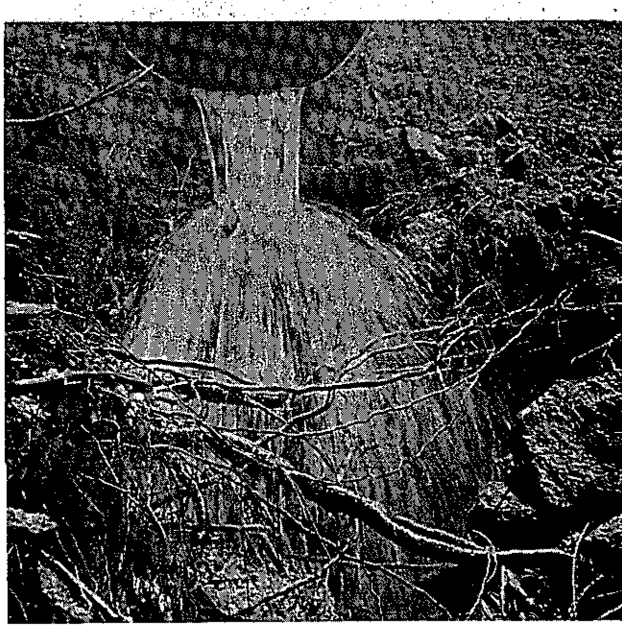
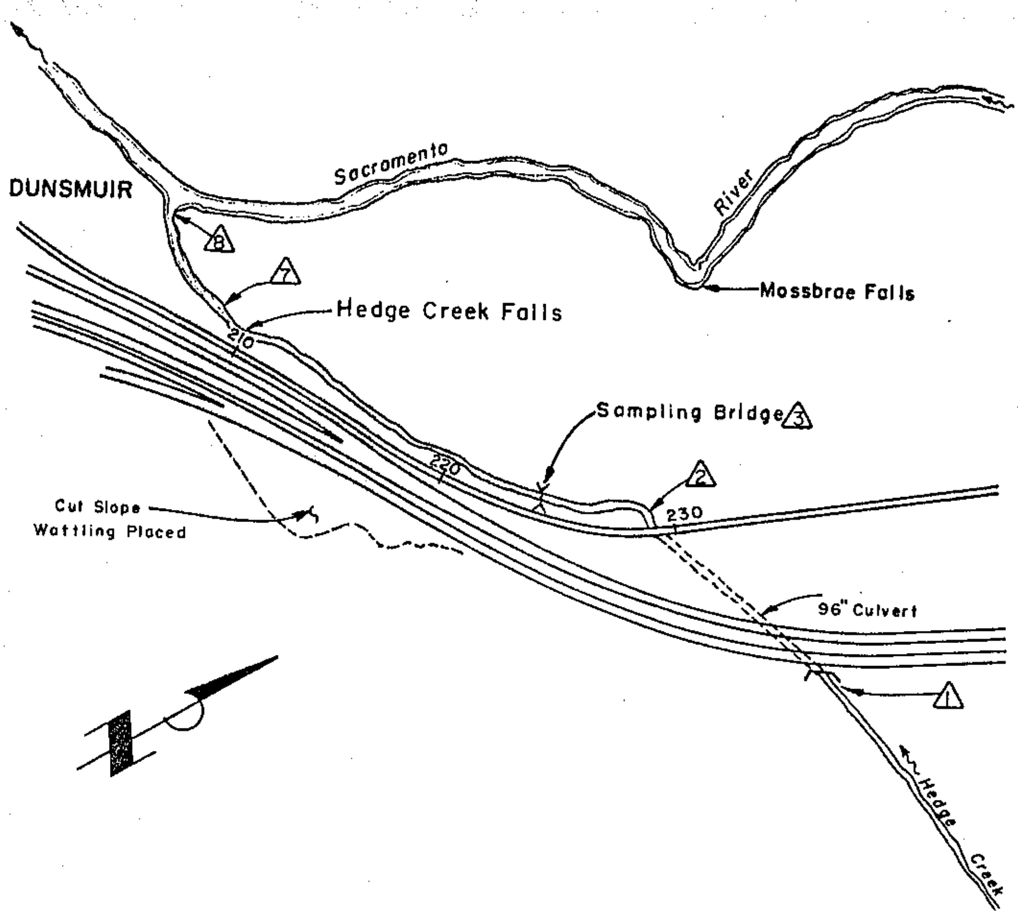


Photo 41

April 14, 1978
Scour Hole Below Culvert 8.
Hole was About 10' x 5' x 4'
Just Below the Culvert and
then Tapered to a 20' x 10'
x 2' Hole



△ Biological Sample Sites

BIOLOGICAL SAMPLE SITES

FIGURE 21

TABLE 27

AQUATIC SPECIES LIST OF HEDGE CREEK

Species	Date I 7/75	II 6/76	III 3/77	IV 11/77	V 1/78	VI 4/78
1. *Hexatoma* Sp 1	X			X		X
2. *Hexatoma* Sp 2				X		
3. *Limnophilia* Sp						X
4. *Ormosia* Sp	X					
5. *Rheotamtarsus* Sp				X		
6. Chironomidae UNK Sp 1	X					X
7. " " Sp 2	X					X
8. " " Sp 3	X					X
9. " " Sp 4	X					X
10. Empididae UNK Sp 1	X					
11. " " Sp 2	X					
12. " " Sp 3	X					
13. Muscidae UNK				X		
14. *Simulium* Sp	X					X
15. *Acroneuria theodora*	X	X	X			
16. *Nemoura* Sp	X					
17. *Paraperla* Sp	X		X			
18. *Hastaperla* Sp		X				X
19. *Peltoperla* Sp		X				
20. *Alloperla* Sp	X					X
21. *Hydropsyche* Sp	X	X				
22. *Parapsyche* Sp	X	X	X			
23. *Arctopsyche* Sp	X					
24. *Ecclisomyia* Sp 1	X	X	X			
25. *Ecclisomyia* Sp 2	X	X				
26. *Lepidostoma* Sp 1	X	X				
27. *Lepidostoma* Sp 2	X					
28. *Neophylax* Sp	X					
29. *Glossosoma* Sp		X				
30. *Rhyacophilia* Sp 1	X	X	X		X	X
31. *Rhyacophilia* Sp 2	X	X				

TABLE 27 (Continued)

Species	Date I 7/75	II 6/76	III 3/77	IV 11/77	V 1/78	VI 4/78
32. *Rhyacophilia* Sp	X					
33. *Rhyacophilia* Sp	X					
34. *Agapetus* Sp						X
35. *Wormaldia* Sp	X	X				X
36. *Tinodes* Sp			X			X
37. *Neureclipsis* Sp			X			
38. *Epeorus* (*Ironodes*) Sp	X	X	X			X
39. *Epeorus* (*Iron*) Sp	X	X				
40. *Epeorus* (*Iron*) *longimanus*	X	X	X			X
41. *Cinygmula* Sp		X	X			X
42. *Ephemerella spinifera*	X	X				
43. *Ephemerella flavilinea*	X	X	X			X
44. *Ephemerella doddsi*	X	X	X			
45. *Ephemerella heterocaudata h.*	X					X
46. *Ephemerella* Sp	X					
47. *Baetis* Sp 1	X		X		X	X
48. *Baetis* Sp 2	X					
49. *Baetis bicaudatus*	X					X
50. *Neocloeon* Sp					X	
51. *Centroptiluun* Sp		X	X			X
52. *Parleptophlebia* Sp 1	X	X				
53. *Parleptophlebia* Sp 2	X					
54. *Ameletus* Sp 1	X					
55. *Ameletus* Sp 2	X					
56. *Narpus* Sp	X					
57. Elmidae UNK	X					
58. *Helochares*		X				
59. *Ametor scabrosus*			X			
60. *Enochrus conjunctus*				X		
61. *Agabus* Sp	X	X				
62. *Deronectes* Sp 1			X			
63. *Deronectes* Sp 2			X			
64. *Acneus* Sp	X					
65. *Oligochaeta*				X		

TABLE 28

TEN AQUATIC SPECIES WITH GREATEST NUMBER OF INDIVIDUALS

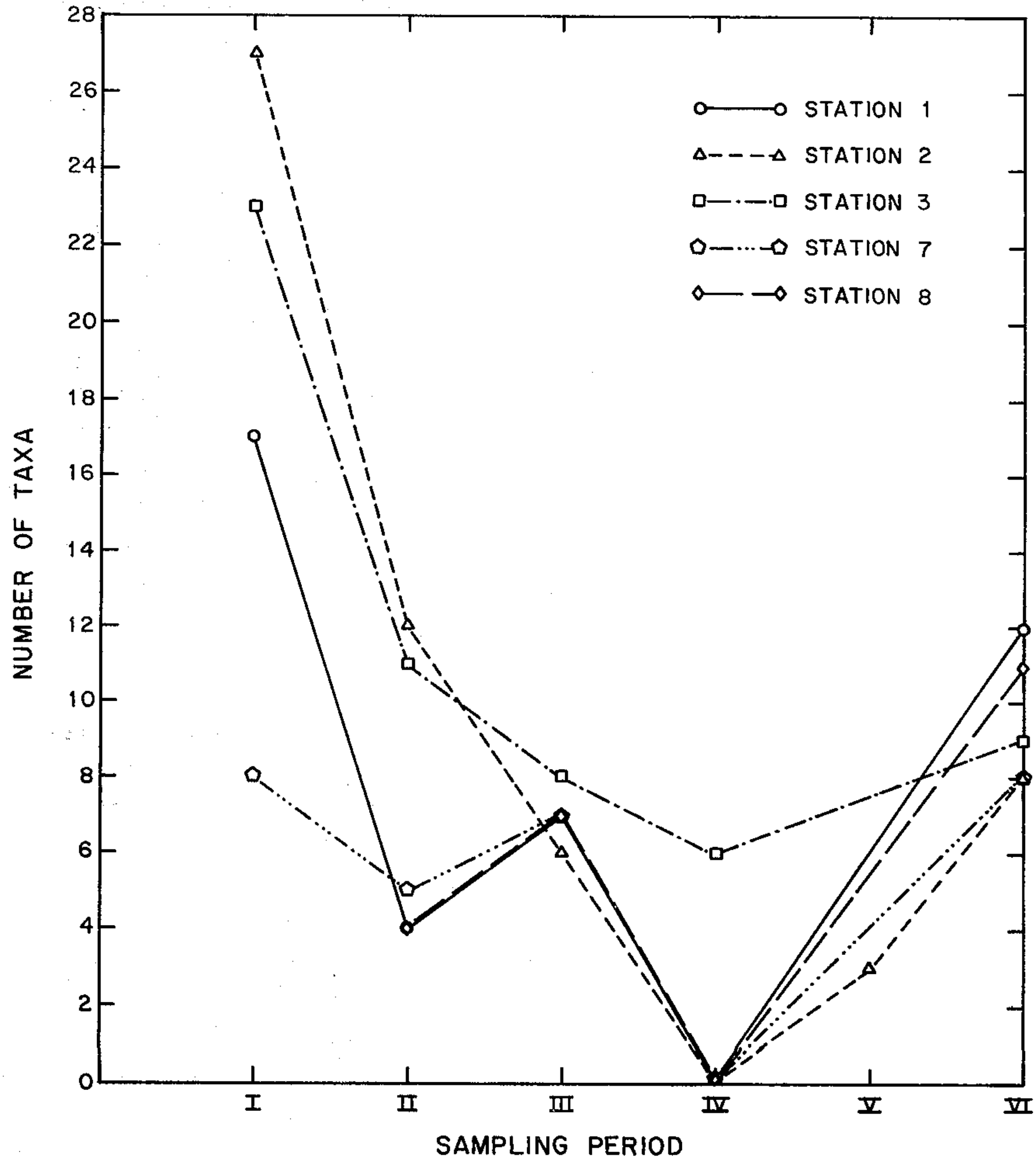
Species	Total Number	Date I 7/75	II 6/76	III 3/77	VI 4/78
Baetis Sp	174	X		X	X
Epeorus (_Iron_)	149	X	X		
Baetis bicandatus	133	X			X
Ephemerella flavilinea	131	X	X	X	X
Epeorus (_Ironodes_)	116	X	X	X	X
Centroptilum	51		X	X	X
Chironomidae	51	X			X
Ecclisomyia	42	X	X	X	
Epeorus (_Iron_) _longimanus_	31	X	X	X	X
Rhyacophilia	27	X	X	X	X

The 10 most abundant species taken as a group represent 82% of the total number of individuals collected. Seven of these ten species belong to the order Ephemeroptera, two belong to the order Tricoptera and one belongs to the order Diptera. The Ephemeroptera are by far the most numerous, six of the seven species having more individuals captured than either of the other orders represented.

While it is recognized that individual species go through life cycles that may preclude their presence during various times of the year, other species will normally be present to occupy the vacated niche. The analysis of macroinvertebrate populations in Hedge Creek used general number of taxa present in each sample to develop the diversity index and did not rely on the presence or absence of individual species.

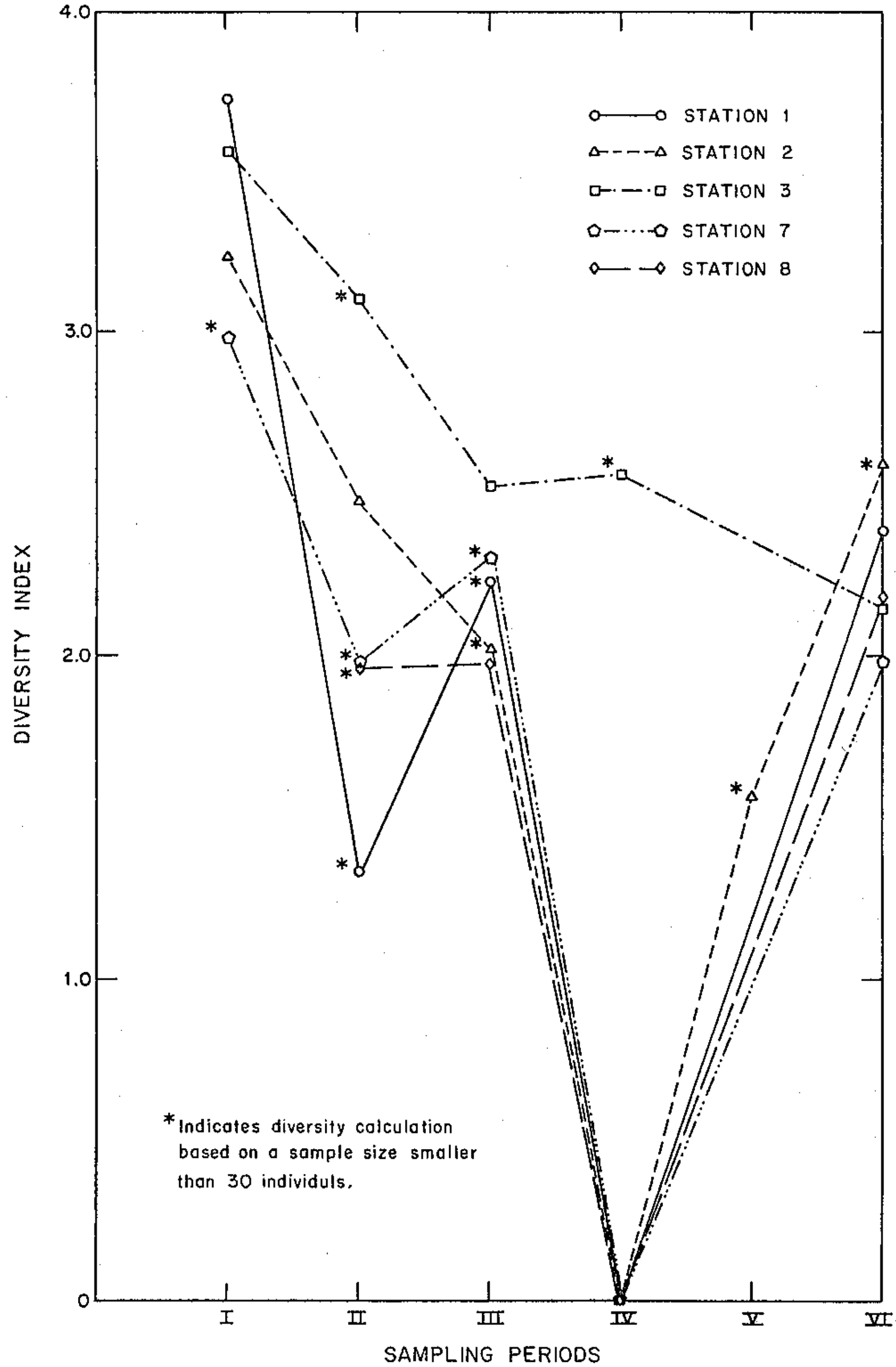
Figure 22 is a comparison of the total number of taxa captured at each station for all sampling periods. Results from Stations 1, 2, 3 and 7 are shown for all sampling periods; results from Station 8 are shown beginning with sample period II and coincide with the results from Station 1 for sampling periods II, III and IV. The number of taxa collected at Station 3, sample period IV is somewhat misleading since only six individuals were captured. Since there were also six species captured, this is a unique sample and is comparable to the other stations during period IV, where no individuals were captured.

The Shannon-Weaver Diversity Index for each station is shown in Figure 23. The diversity indexes were calculated to show the general health of the ecosystem. Their use in evaluating impacts is marginal because of changes in stream flow and time of the year when collections were



A COMPARISON OF THE TOTAL NUMBER OF TAXA COLLECTED

FIGURE 22



A COMPARISON OF THE DIVERSITY INDEX FOR EACH SITE

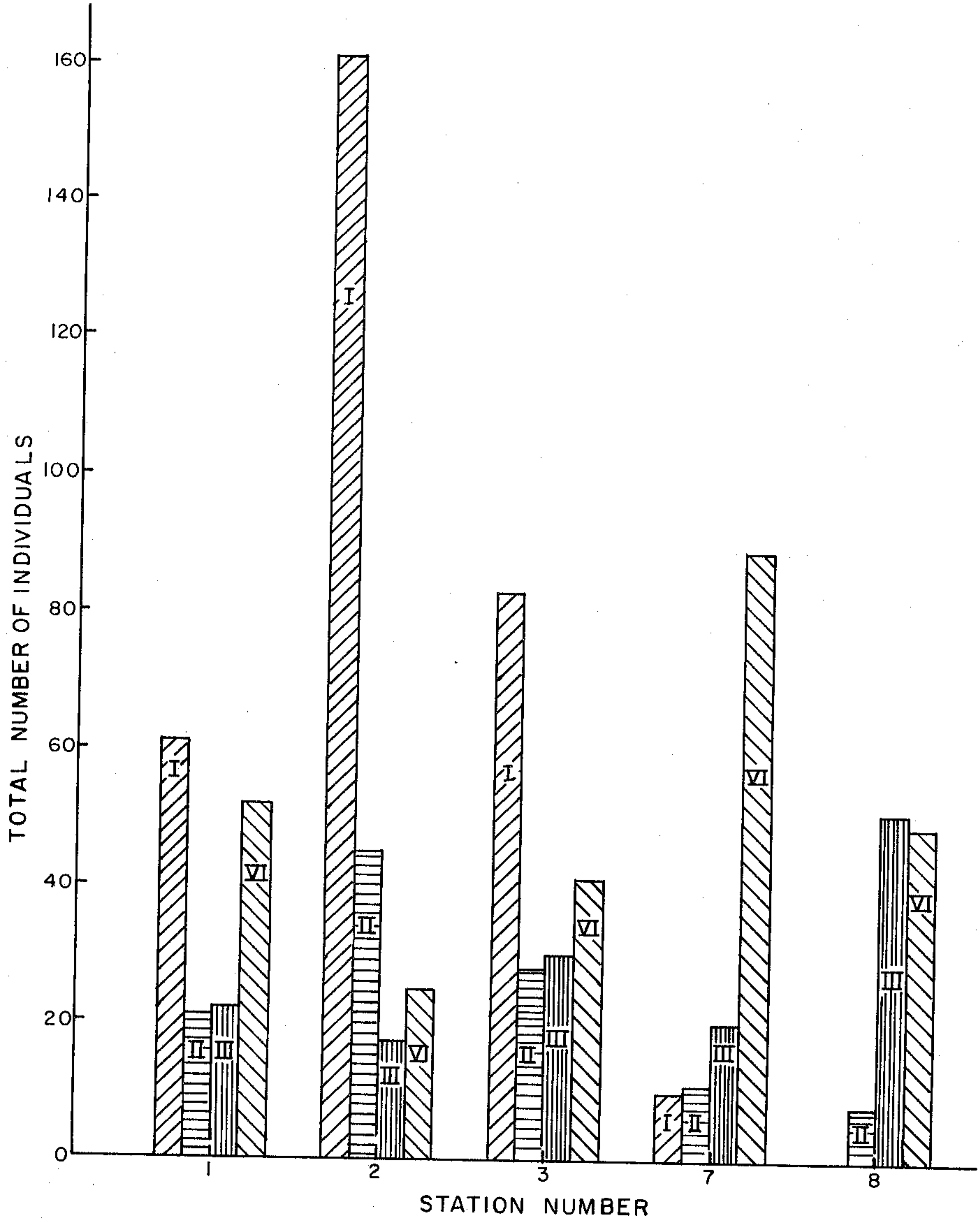
FIGURE 23

made. The actual values calculated are, for the most part, unreliable because of low numbers of individuals captured. Only one station, Station 2, sample period I, having greater than 100 individuals, gives a reliable diversity index. Of the others shown, those stations with asterisks have fewer than 30 individuals and are not reliable, but are shown for consistency.

Of more interest is Figure 24, which shows the total number of individuals captured at each station for each sampling period. Only results from sampling periods I, II, III and VI are shown, since during sample period IV only one site produced any individuals and during sample period V only one site was sampled. Station 8 has only sampling period II, III and VI shown since it was not sampled during period I, but added to the sampling program beginning with period II.

These data indicate an overall decrease in the numbers and kinds of aquatic biota in Hedge Creek. It is felt that the construction of the highway and the rechannelization of Hedge Creek contributed to the decrease observed. However, the effect on Hedge Creek is complicated by an extensive drought that occurred throughout California during the monitoring period, so that definite statements concerning the construction effects cannot be made.

Decrease in macroinvertebrate populations can occur through the loss of habitat and changes in environmental conditions. Severe reduction in water levels will cause a decrease macroinvertebrate populations through loss of habitat. However, Larimore, Childers and Hechrotte (1959) showed that recolonization of a stream by aquatic invertebrates following a drought is rapid. In addition, we have found



COMPARISON OF TOTAL NUMBER OF INDIVIDUALS COLLECTED

FIGURE 24

large and diverse populations in streams with flows less than 1 cfs. The macroinvertebrate populations adjust to alternating wet and dry periods by being either exceptionally hardy or having short life cycles. In each case, the substrate was unaffected.

Hedge Creek was subjected to heavy siltations prior to the drought which severely restricted the habitat available during and after the drought. Even after water levels returned to normal, the silt and sand limited the recolonization of Hedge Creek.

The total decrease in macroinvertebrate populations can be attributed to both the drought and siltation. The length of time to recover, however, has been greatly extended by the heavy siltation. The silt and sand deposits in the creek came during construction. If normal rainfall had occurred during this period, the silt may have been washed out of the stream and little effect would have been observed.

An example of this effect can be seen in the results from site 7, sample periods I and II where silt from road construction had damaged the site prior to sample period I and it had not recovered by sample period II. The aquatic macroinvertebrate population can recover rapidly from environmental damage, but only if the stream habitat recovers first.

Summary

The Environmental Impact Statement (EIS) was submitted on November 30, 1973(23). Several probable, unavoidable adverse effects to water quality, aesthetics and fishery were identified. Also, mitigation measures were recommended in the EIS to minimize or eliminate these effects. These were discussed earlier in the "Environmental Study (Preconstruction)" section for Hedge Creek.

This section will discuss the adequacy of the mitigation measures and bring to attention effects that were not covered by the EIS.

1. Aesthetics and Erosion

The revegetation plan for the large cut slope (Planting Location 2) consisted of placement of willow wattling, willow cuttings, seed, seedlings and container plants to minimize the aesthetic and erosion impacts of the denuded slope.

The survival of the wattling, installed in June and July 1975 was poor. Several reasons accounted for the poor survival, the main one being that it was the wrong time of the year (summer) for installation. The soil was very dry during installation. Timing is very important in any revegetation procedure. Enforcement of the project Special Provisions that prescribe the time of year for planting is essential to ensure plant establishment.

The grass seed was applied in the fall of 1975. The willow cuttings, container plants and seedlings were not planted in fall 1975, as scheduled, due to unavailability of the various native plants and seedlings.

During the 1975-76 winter, some erosion was noted on the large cut slope. Had this winter been normal in terms of precipitation, and not a drought condition, considerable erosion probably would have occurred, causing large amounts of sediment to accumulate on the highway and in Hedge Creek. The willow wattling lessened the effects of the erosion by catching the soil. Grass seed was caught along with the soil, as indicated in the spring 1976, by the grass growth along the rows of wattling bundles. Eventually the grass spread throughout the slope.

The willow cuttings, container plants and seedlings were placed in fall 1976. The soil was very dry during the planting. Surprisingly, even under these severe conditions, the survival of the plants was fair.

A field review of the vegetation, made on May 4, 1978, indicated very little growth of the wattling. Grass growth was very good, probably due to the structural aspect of the wattling in allowing a place for seed to catch and then germinate. Without the structural aspect of the wattling, the seed would have been carried down the slope with the eroding material. Survival of the plant material was fair.

The mitigation measures to control slope erosion and improve the aesthetics were adequate. Additional attention to time of placement of the vegetation, along with an understanding of the method of placement will improve the survival of these vegetative measures. For future contracts, these precautions should be spelled out in the special provisions.

2. Construction Impacts

During the summer 1975, construction season, soil deposited on the roadway by construction activities was washed by the contractor along the existing highway to a culvert that drains into Hedge Creek below the falls. Clay and silt from this daily operation covered the creek bottom and virtually eliminated the macroinvertebrates in this section of stream. A settlement basin was constructed to settle the soil particles before its' discharge into Hedge Creek. This basin performed well, eliminating additional sedimentation in Hedge Creek, but the damage was done. Approximately 2 years were needed before the winter rains had flushed most of the sediment to the Sacramento River and the stream had recovered to a point where macroinvertebrates were observed. The abnormally low flows during the drought compounded the problem.

In this case, the mitigation measure was adequate, but it was not implemented until after severe impact to the stream occurred.

3. Sedimentation Impacts on the Fishery

During the winters 1975-76, 1976-77 and 1977-78, erosion of the newly exposed cut slopes and constructed fill slopes varied. In most areas, little erosion occurred, but in a few isolated areas significant amounts of erosion took place. Gully erosion was indicative of these severely eroding areas. It is difficult to determine the impact to the Hedge Creek fishery from this sediment because of earlier sedimentation during construction. In July 1977, 8 trout were found dead near the outlet of the 96-inch culvert. Portions of the stream had dried up due to the drought.

The 500 feet of new channel were constructed in June 1975. During this period, the flow in Hedge Creek was very low (approximately 1 cubic foot per second); therefore, erosion and siltation from the channel diversion and construction of the new channel were slight.

4. Impacts Not Identified in the EIS

There were two possible impacts that were not addressed in the EIS. One was the effect on the fish and macroinvertebrates due to the increase in water temperature in the realigned channel during the summer months, before stream-side vegetation was reestablished. As it was, the stream dried up during the summer periods of 1976 and 1977, so this impact was not realized. The growth of the willow cuttings and native alders has lessened and eventually will diminish the impact totally.

A second impact was the scouring that took place below Culverts 6, 7, 8 and 9 (see Figure 20). Mitigation measures to prevent scour at the outlets, such as riprap, grouting, etc., should have been addressed.

Temporary construction impacts were not foreseen in the EIS study.

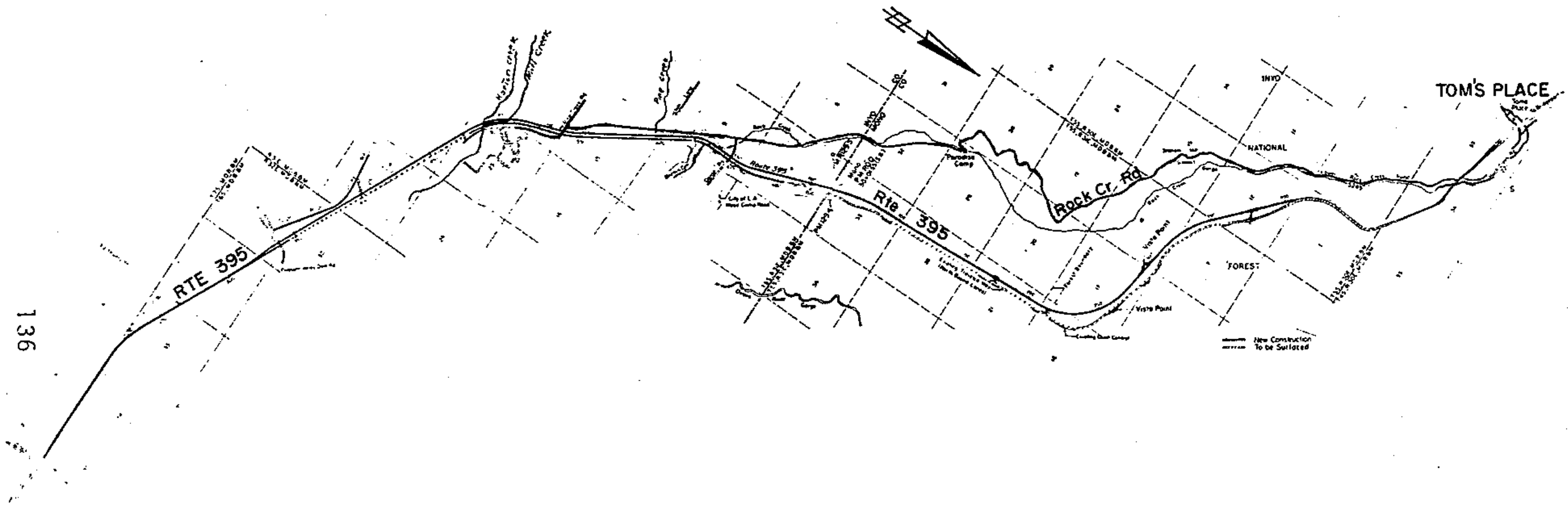
ROUTE 395, ROUND VALLEY TO UPPER SHERWIN GRADE (ROCK CREEK)

The Route 395 project is located on the east slopes of the Sierra Nevada Mountains. The northern end of the project is above 7,000 foot elevation and the southern end is about 4,500 feet. The town of Bishop is located approximately 2 miles southeasterly of the southern project terminus. Route 395 is a north-south route that begins in San Bernardino and continues northerly along the eastern portion of the Sierra Nevada and into the eastern portion of Oregon and Washington. It serves as a major north-south artery for travelers from the Reno-Sparks, area in the north and the greater Los Angeles area in the south. It provides access for recreationists seeking to utilize the varied outdoor opportunities that exist in the Mojave desert region and high mountain areas. Both Mt. Whitney, the highest mountain located in the continental U.S., and Death Valley National Monument, the lowest point in the continental U.S., lie less than 100 miles to the south of the project.

Conversion of Route 395 into a 4-lane divided freeway took place over a 5-year period with 3 construction projects as follows (see Figure 25):

TABLE 29
PROJECT LOCATIONS

Project	Post Mile Limits	Year
Round Valley	118.4 to 129.4 (Inyo Co.)	1973-74
Sherwin Grade	128.9 to 129.4 (Inyo Co.)/ 0.00 to 6.9 (Mono Co.)	1974-76
Upper Sherwin Grade	8.3 to 9.9 (Mono Co.)	1976-77



ROUTE 395, ROUND VALLEY TO UPPER SHERWIN GRADE

FIGURE 25

The existing 2-lane highway was utilized as much as possible for the northbound lanes and the southbound lanes were constructed on a separated alignment for the majority of the project.

Rock Creek, a high-quality freshwater trout stream, flows under Route 395 near Sherwin Grade Summit and then follows along the freeway to the west approximately 0.5 to 1 mile. The creek passes through a deep canyon called Rock Creek Gorge before emerging near the southern end of Route 395 project where it flows under the freeway to the east. Lower Rock Creek Road, a county-maintained road and formerly a state highway, follows the creek alignment between the northern and southern crossings of the freeway.

Near the lower end of the project (Round Valley), three additional creeks are crossed as they flow easterly from the slopes of the Sierra Nevada Mountains. They are Pine Creek, Mill Creek, and Horton Creek. The water is partially used for agricultural and some domestic use. However, most of the water is under the control of the Los Angeles Department of Water and Power which exports the water to southern California via the Owens River Aqueduct.

The area traversed by the project lies in the rain shadow of the high Sierra Nevada Mountains and consequently the vegetation reflects the typical arid high desert climate. Precipitation varies from over 10 inches/year near the 7,000 foot level to about 6 inches/year at the southern end of the project. During the winter, most of the precipitation at the higher elevations is in the form of snow. A significant amount of stream flow originates from groundwater seepage.

Environmental Study

The District 09 Environmental Unit of the Materials Department performed a water-quality study on Rock Creek during the period of June 1973 to March 1976(30). In addition, an erosion survey was completed in October 1974, for the Upper Sherwin Grade project(31). Information from these studies follows.

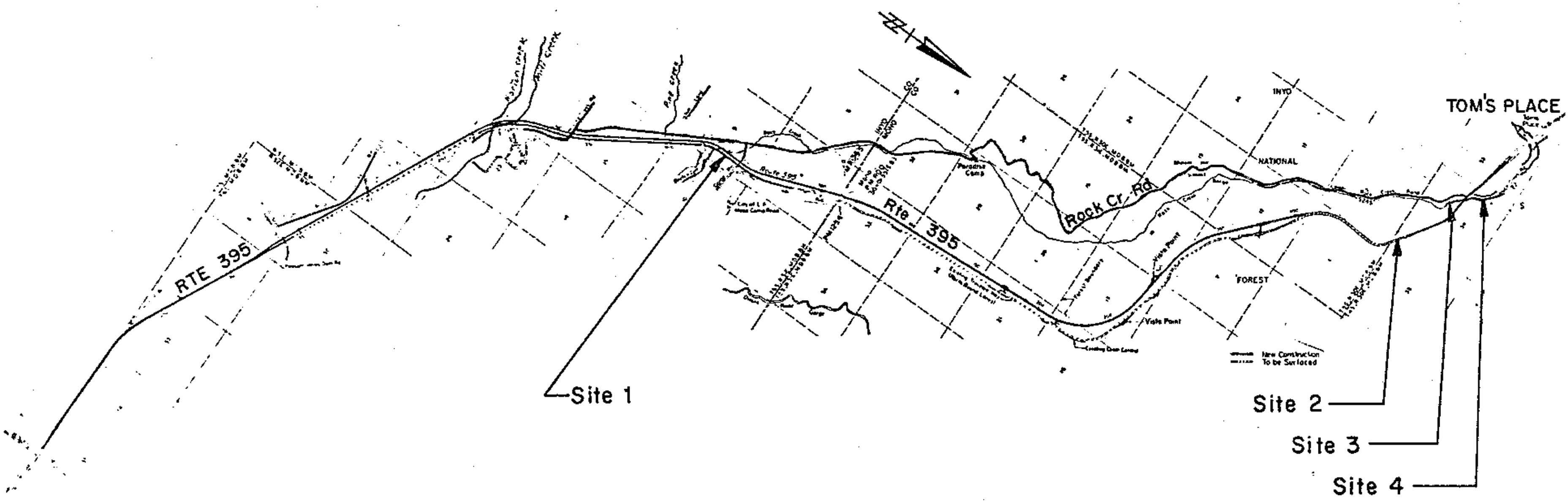
Rock Creek is a major trout fishing stream that flows year round. Average monthly flows for 12 calender years of record are shown in Table 30(32).

TABLE 30
AVERAGE MONTHLY FLOWS, cfs

Jan.	Feb.	March	April	May	June
13.6	12.7	12.6	16.0	21.7	25.0
July	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
23.7	19.7	15.9	13.6	12.9	12.8

The highest flows occur during the May-July period, which represents peak snowmelt from the winter snowfall. The Department of Fish and Game stocks Rock Creek with rainbow trout (Salmo gairdnerii). There is also an established, but small, brown trout (Salmo trutta) population.

The district water-quality-field investigation included sampling Rock Creek at 4 locations as shown in Figure 26. The distance between Site 1 and Sites 2-4 is approximately 20 miles. A description of the sites is given in Table 31.



SAMPLING SITES

FIGURE 26

TABLE 31
SITE DESCRIPTION

Site	Location
1	Located 200 feet upstream from new Rock Creek crossing in Round Valley near P.M. 128 Inyo Co.
2	Located 1/2 mile below the Rock Creek crossing near Sherwin Grade Summit P.M. 9.0 Mono Co.
3	Located 900 feet below the Rock Creek crossing near Sherwin Grade Summit P.M. 9.2 Mono Co.
4	Located 100 feet above the Rock Creek crossing near Sherwin Grade Summit P.M. 9.2 Mono Co.

Water samples were taken by randomly grabbing a sample and field testing for temperature, pH, dissolved oxygen, and conductivity. Other constituents were tested in the District Water Testing Laboratory which is designated an approved water testing laboratory by the Department of Health Services. Results of the water testing are shown in Table 32.

The test data reflect excellent water quality in Rock Creek, particularly in its upper reaches (Sites 2-4). Site 1 data shows higher nitrate, specific conductivity, sulfate and turbidity than the other sites, because it is located near pasturelands and some of the flow in this vicinity of Rock Creek consists of irrigation return water. Also, primarily due to the lower elevation and thus warmer temperatures, the water temperatures were slightly higher at Site 1 than at Sherwin Grade.

TABLE 32

WATER TEST RESULTS (RANGE)

Rock Creek

Parameter	Site 1	Site 2	Site 3	Site 4
Alkalinity, mg/l	0.5 - 78(21)*	18 - 23(4)	11 - 23(4)	9 - 41(23
Chloride, mg/l	0.7 - 8.3(20)	0 (3)	0 - 7.6(5)	0 - 7.6(22)
Dissolved Oxygen, % Sat.	95 - 101(17)	103 - 110(3)	101 - 125(12)	97 - 113(23)
Filterable Residue	-**	16 - 32(10)	14 - 40(14)	8 - 40(26)
Non-filterable Residue	-**	0 - 5(10)	1 - 30(22)	1 - 10(34)
Fluoride, mg/l	<0.2 - 0.84(21)	<0.2(3)	<0.2(6)	<0.2 - 0.2(23)
Hardness, mg/l	36 - 145(21)	18 - 69(4)	8 - 56(8)	4 - 123(26)
Nitrate-Nitrogen, mg/l	0.3 - 16.4(18)	<0.5(3)	<0.5(2)	<0.5 - 2.7(19)
pH	6.9 - 8.6(24)	7.4 - 8.4(11)	7.3 - 9.4(17)	7.2 - 8.8(29)
Specific Conductivity, µmhos/cm	100 - 430(27)	20 - 40(10)	18 - 50(14)	10 - 50(26)
Sulfate, mg/l	15 - 134(21)	<5(3)	0 - 3(8)	0 - 4.8(26)
Temperature, C	3 - 22(25)	0 - 10(10)	0 - 17(18)	0 - 17(28)
Turbidity, NTU	0.3 - 5.1(29)	0.3 - 3.1(11)	0.3 - 1.7(21)	0.3 - 1.9(34)

*Number in ( ) is number of water samples tested.
**At Site 1, suspended solids were measured and ranged from 2.8 to 60.1(28).

All of the recorded data show that the stream quality is within the water-quality objectives for Basin Plan 1B, South Lahontan Water Quality Control Plan(33).

The realignment of portions of Rock Creek and construction of the reinforced concrete box near the southern terminus of the project appeared to be the major potential impact areas. Special precautions were delineated in the project Special Provisions for stream protection during construction.

For the upper portion of the project located near Sherwin Grade Summit, an extension of the reinforced concrete box at Rock Creek was required. At the outlet, a portion of Rock Creek had to be realigned to match the existing channel downstream from the proposed embankment.

Because of the excellent water quality and the potential for adversely impacting the creek, primarily from fine silt and eroded sediment, special precautions were included in the contract Special Provisions.

An erosion survey was performed for the Upper Sherwin Grade portion of the project because of the nearness of the embankment to Rock Creek and proposed cut slopes in the area(31). A summary of the district report indicates that about 12,500 cubic yards of material have been eroded from existing road slopes in the vicinity of the upper project over an 18-year period. The study estimated that about 42 cubic yards per year enter Rock Creek in the upper area. The major source of sediment that appeared to be readily available for transport into Rock Creek was the adjacent fill slopes.

Mitigation measures were delineated for the new fill slopes to reduce this potential source on the new project. One unique aspect of the mitigation was the utilization of brush layering in the fill and application of fiberglass roving at the crest of the fill.

Construction Monitoring

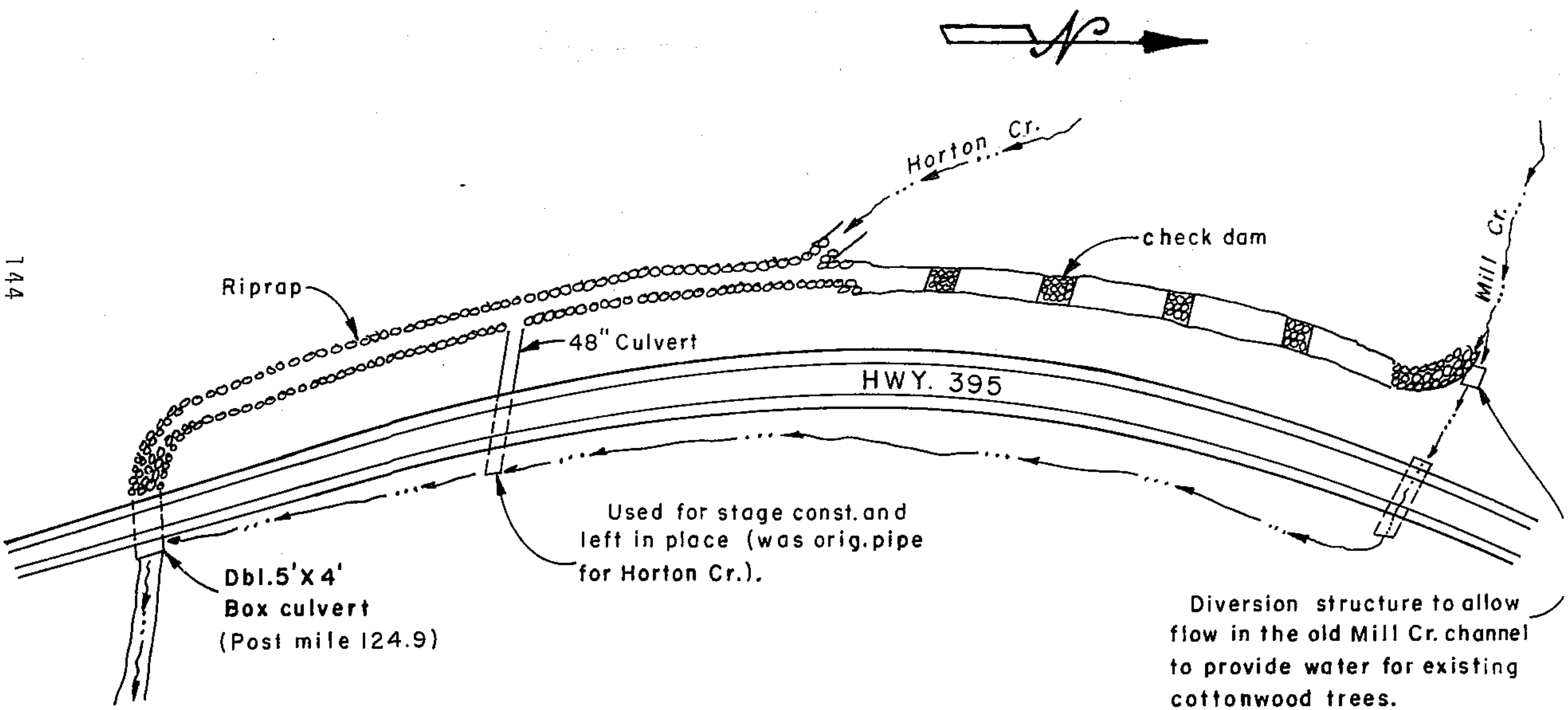
Construction took place on the Round Valley job (P.M. 118.4 to 129.4 Inyo Co.) in 1975. Because of the direct involvement with realignment of portions of Rock Creek, Mill Creek, Horton Creek, and Pine Creek, special attention was given to monitoring these projects to insure compliance with the Lahontan Regional Water Quality Control Board Waste Discharge Requirements. Figures 27 and 28 show the areas affected.

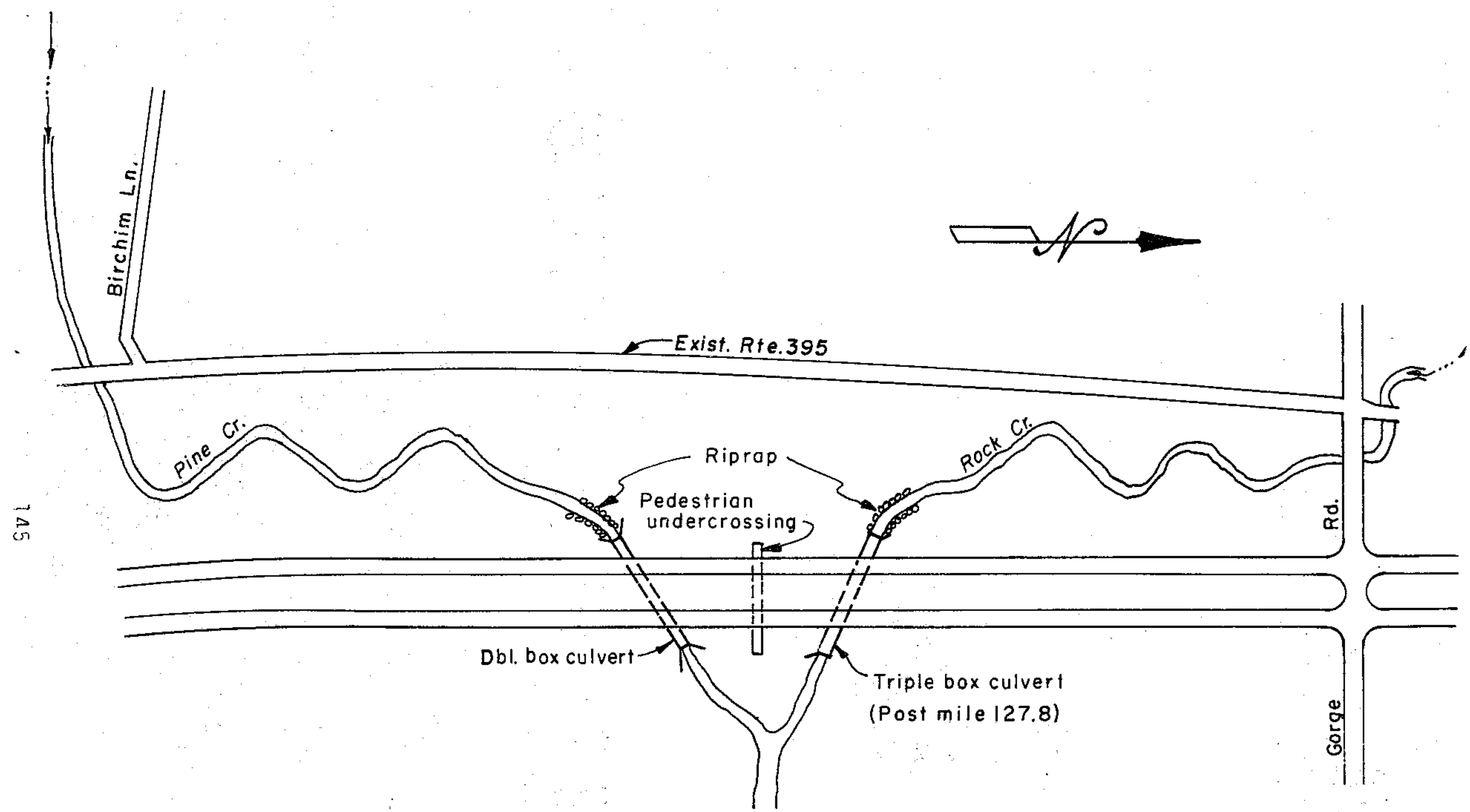
The Caltrans District 09 Environmental Unit monitored water quality and made necessary adjustments to maintain good water quality in the affected streams. A reporting of water quality test results was made and forwarded to the Lahontan Regional Water Quality Control Board (Lahontan RWQCB) along with photographs of the project construction.

An overview of the construction (January 1975 - October 1975) of the Round Valley project is shown in the following photos.

Figure 27

CHANNEL REALIGNMENT





STREAM ALTERATIONS

Figure 28

Photo 42 shows the construction of a temporary channel of Rock Creek. Sand bags are in place to hold stream while the channel is excavated up to the existing stream. Diversion will be made by removing the bags by hand and gradually placing them across the existing channel to divert water.

Photo 42

Photo 43 shows Rock Creek running clear, and turbidity tests taken at this time (2 days after diversion) indicated that the water flowing out of the temporary channel was as clear as that flowing in (about 2 to 3 N.T.U.).

Photo 43

Photo 44 is a temporary channel change during construction showing how sandbags are used to keep the existing stream out of the work area at the outlet end, and the use of a check dam in the channel to reduce velocity. (8'x8' box for use of fishermen is shown under construction above the left bank - it is not intended to carry water.)

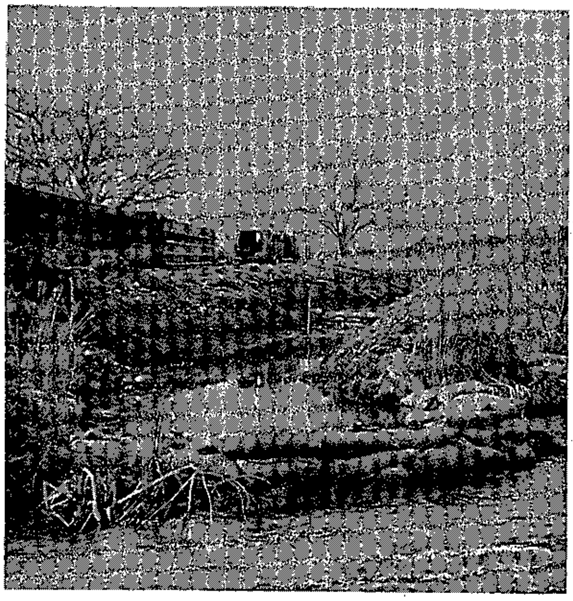


Photo 44

Photo 45 is the Rock Creek channel change showing sand bag checks in place to slow velocity.

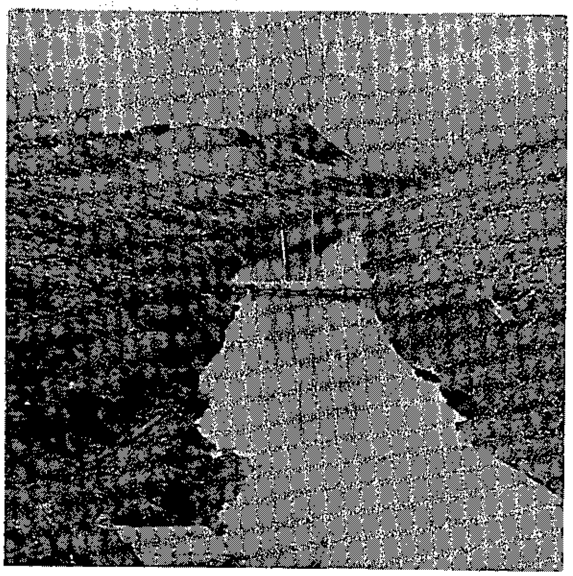


Photo 45

Inlet end of Rock Creek diversion channel is shown in Photo 46 where sacked riprap is used to divert water from natural channel on right.

Photo 46

Water in temporary channel change of Rock Creek is flowing clear two to three days after diversion in Photo 47.

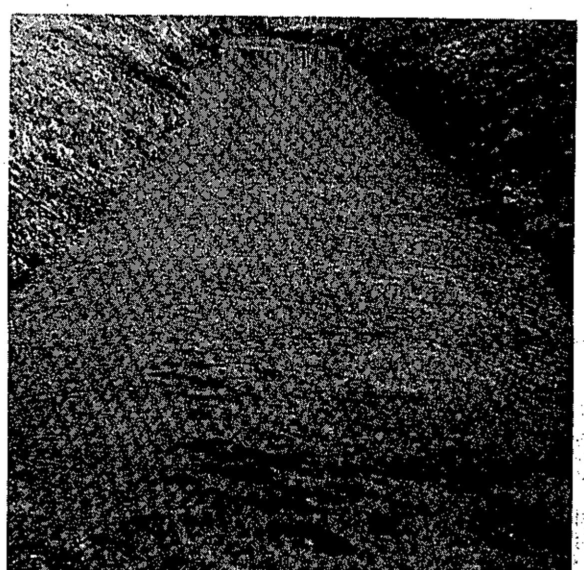


Photo 47

Sandbag check dam was used to slow velocity and reduce sediments from spring water flowing from natural channel of Pine Creek after main flow had been diverted (Photo 48).

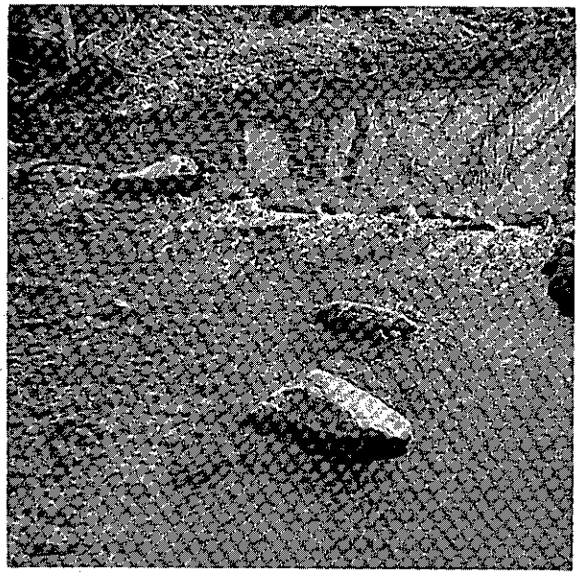


Photo 48

Photo 49 is a typical view of flowing streams on this project (Mill Creek). Mill Creek is one of four live streams which cross the highway alignment. This picture was taken before any work was done. Note the vertical banks and material which has fallen into stream.

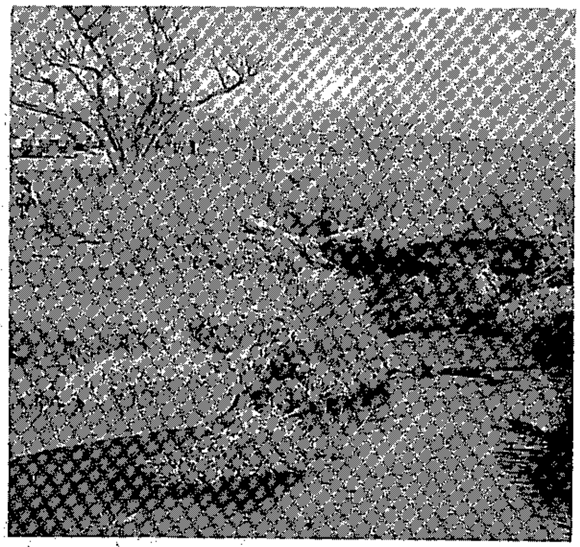


Photo 49

Photo 50 is a picture of the permanent channel change under construction on Mill Creek. Note the wide bottom (12') and 2:1 side slopes. A series of rock check dams will be installed later to reduce velocities.

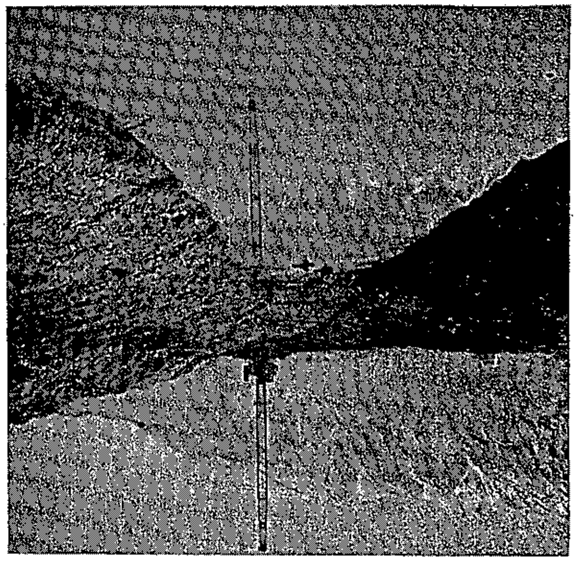


Photo 50

Photo 51 shows the placement of a pipe for temporary crossing in Horton Creek.

Photo 51

In selecting the temporary crossing sites, an attempt was made to pick areas where the existing streambed was uniform so that pipes could be placed with little or no preparation of streambed. However, some minor work was sometimes necessary. Photo 52 shows the hand placement of sand bags at the inlet end of a temporary pipe on Horton Creek.

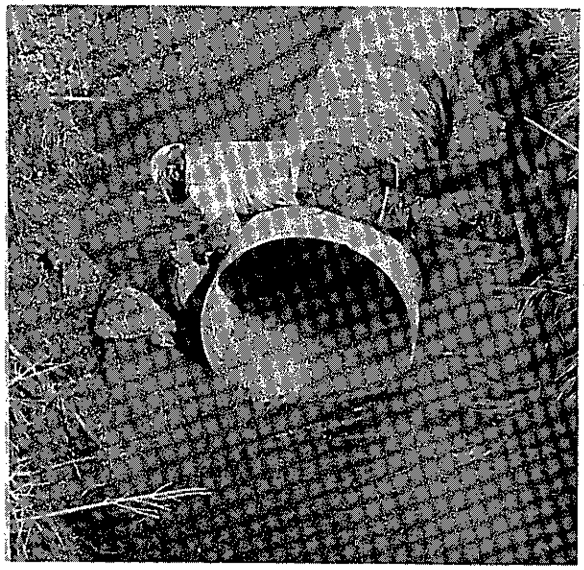


Photo 52

Photo 53 shows sand bags in place at outlet end of temporary pipe for equipment crossing. Note muddy water that is trapped behind sand bags.

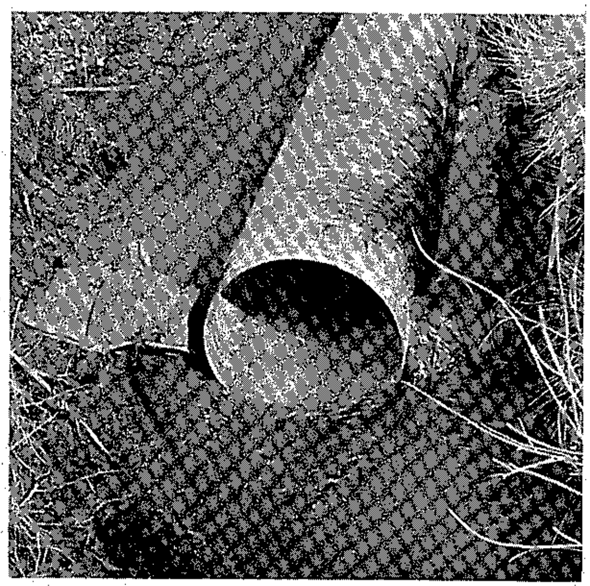


Photo 53

Photo 54 shows completed temporary equipment crossing after backfill has been placed.

Photo 54

After the temporary channel diversions were completed, work proceeded on the permanent channel crossings. Photo 55 shows the completed structure crossing of Rock Creek near the highway connection to the old highway which is now a county road.

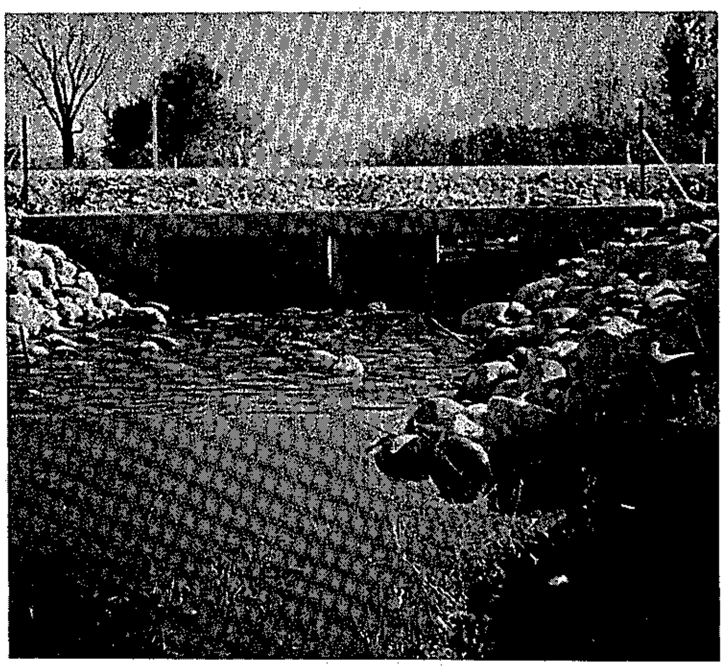


Photo 55

Photo 56 shows the outlet of Rock Creek at the highway 395 crossing with 1/4 ton rock placed in the stream.

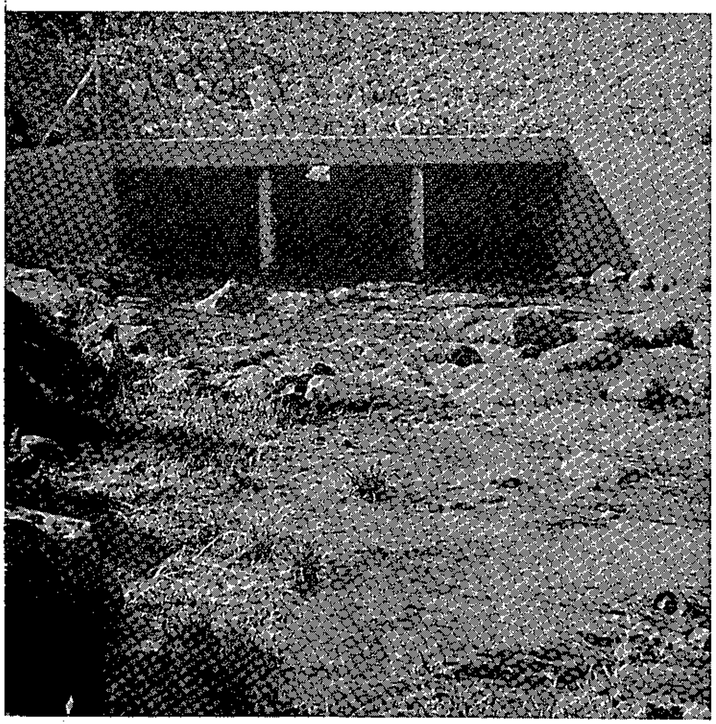


Photo 56

Looking downstream on Rock Creek from highway 395, Photo 57 shows the reconstructed channel blending in with the natural channel.

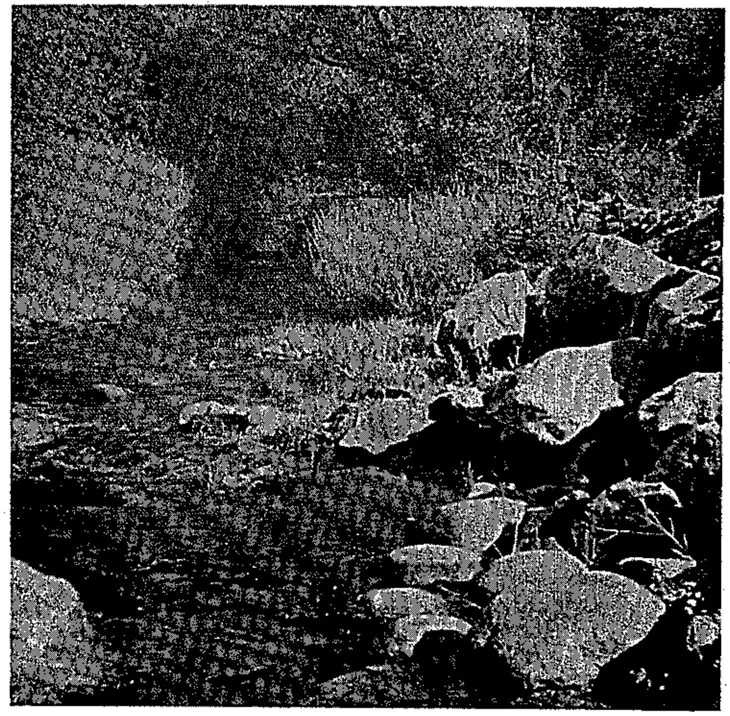


Photo 57

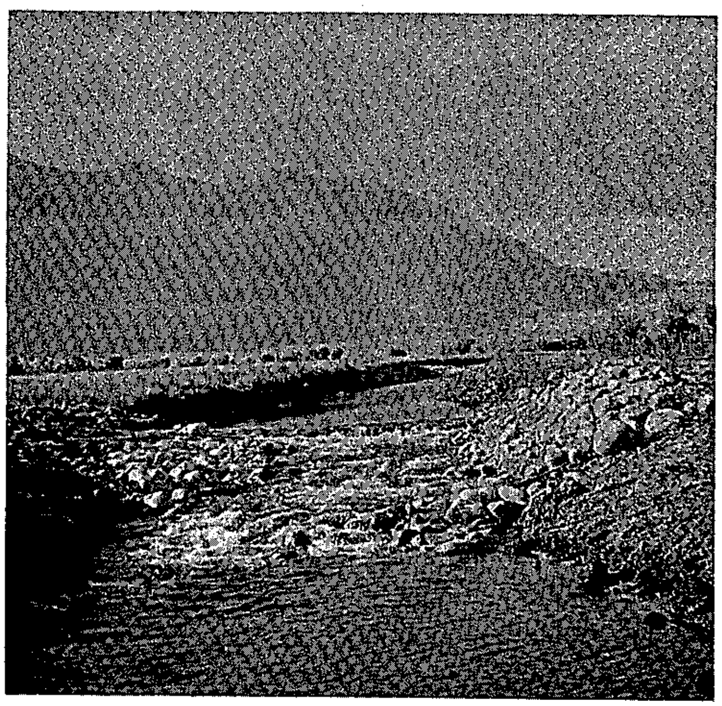


Photo 58

Horton Creek was riprapped throughout its realigned section to prevent streambank scour. Photo 59 shows the completed channel.

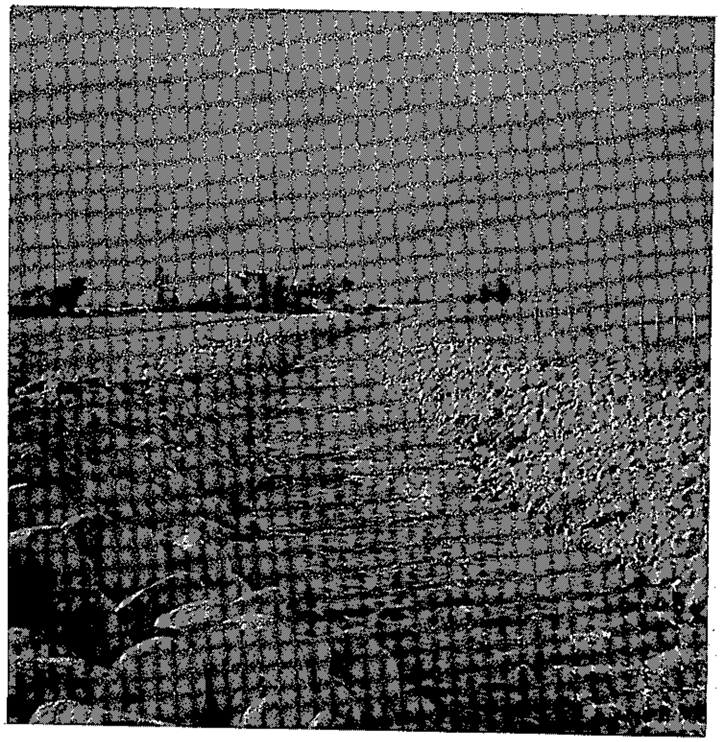


Photo 59

Photo 60 shows Horton Creek as it flows under highway 395

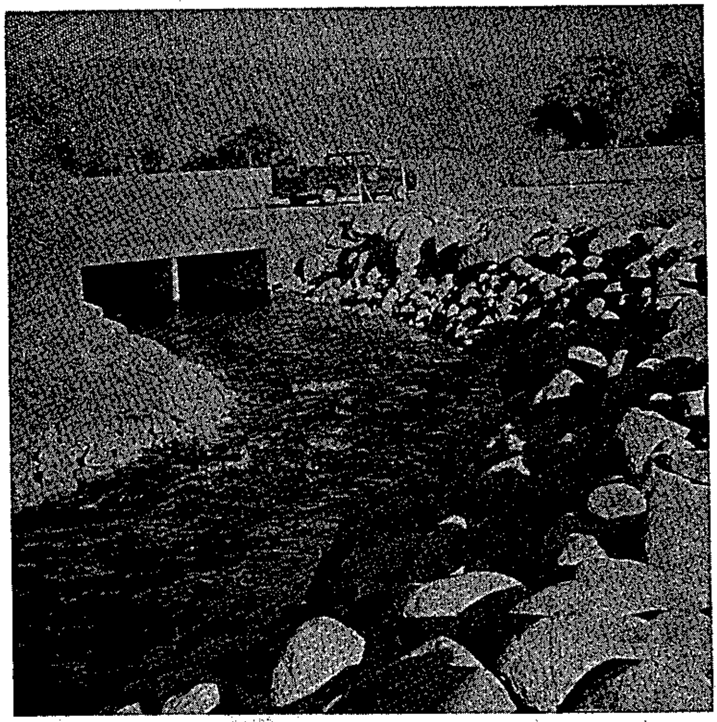


Photo 60

The new highway in Round Valley was completed in 1974. Photo 61 shows the new southbound lanes.

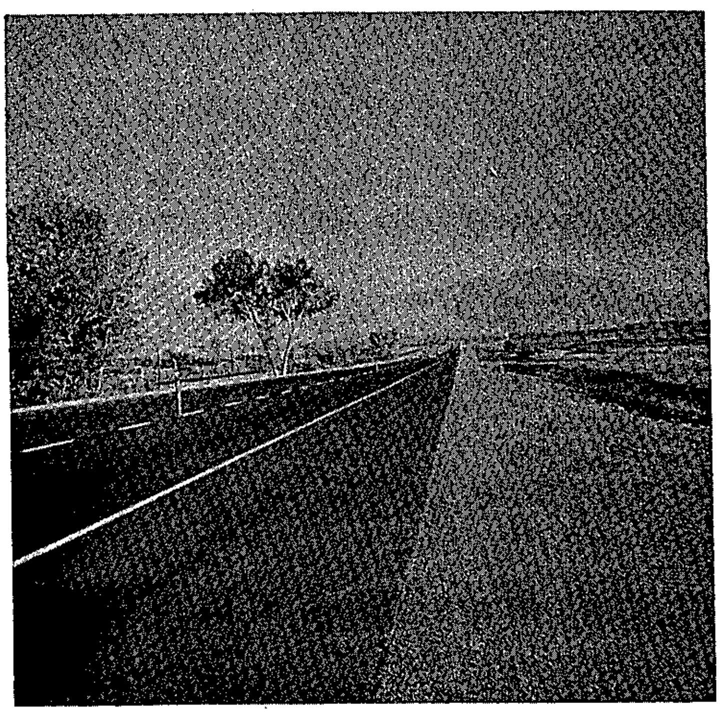


Photo 61

The reconstruction of the creeks and temporary diversions were accomplished with minimal disturbance to water quality. Waters were influenced temporarily by murkiness when diversions were made, but the water returned to very clean conditions within a matter of a few hours. Installation of temporary sediment and erosion-control measures accounted for the success in maintaining water quality. Permanent-erosion-control measures continue to protect the stream quality.

The Sherwin Grade construction project, which was the second project, was built in the period 1974-76. This project involved the long grade up to the summit. No immediate contact with live streams was experienced on this job. Inspection was maintained for temporary erosion.

During construction the contractor laid a temporary pipeline along the shoulder of the road to bring water to the jobsite. The source of the water was Rock Creek above the construction limits. During the removal of the pipeline, a water truck driver started the pump to fill his truck from the partially removed line. The pump was left on for a couple of hours allowing water to be discharged down a gully into Rock Creek. A considerable amount of sediment was washed into Rock Creek. The contractor shut the water off and repaired the pipeline. There was some confusion as to the need for removing the sediment from the stream or not and who would pay for the work. The Lahontan Regional Water Quality Control Board issued a cease and desist order and also a cleanup abatement order. It was finally decided that the contractor would remove the sediment and the cost would be shared between Caltrans and the contractor. Following the cleanup, the stream returned to its normal good quality.

The last of the three construction projects was the Upper Sherwin Grade (P.M. 8.3 to 9.9 in Mono County) constructed in 1976-77 (see Figure 29). This project affected the crossing of Rock Creek near the summit of Sherwin Grade and subsequently required close attention to insure protection of the water quality.

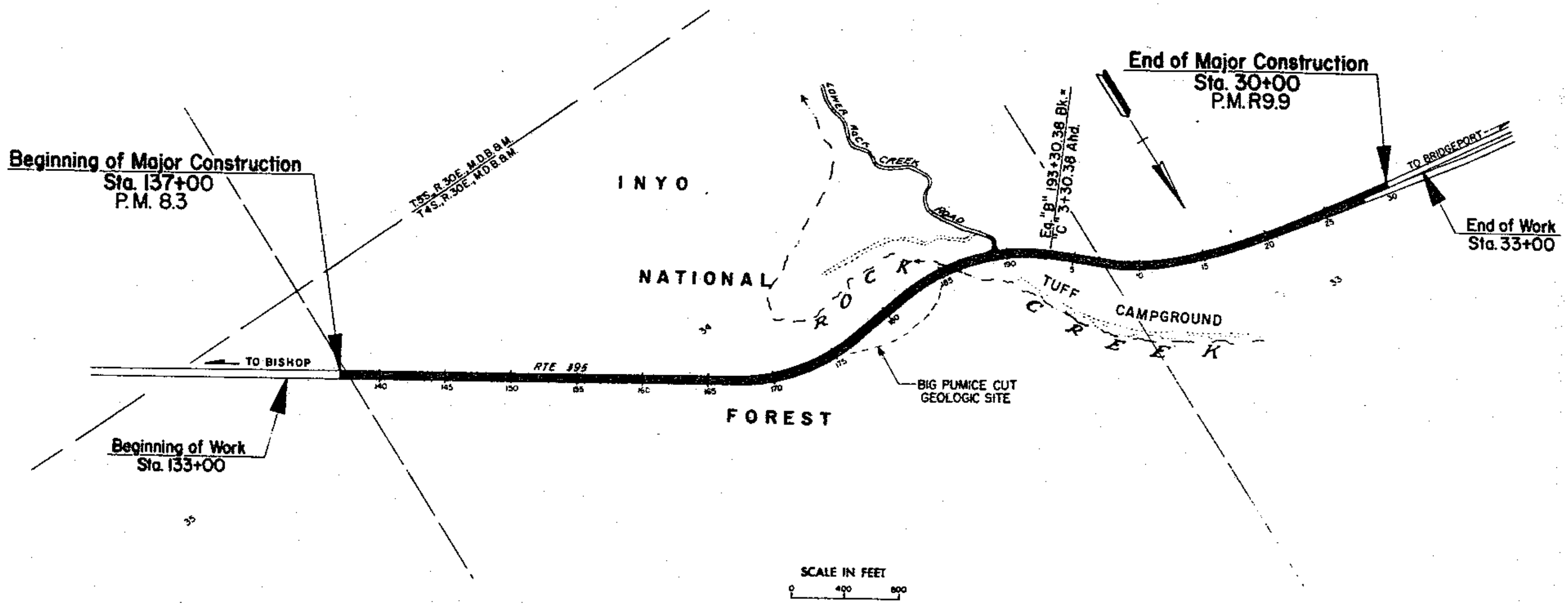
The landforms have been formed from glacial deposits from the eastern slope of the nearby Sierra Nevadas, and from volcanic deposits from a large collapsed volcanic caldera known as Long Valley. The highway slopes are constructed of glacial till and volcanic tuff. Both of these materials are erosive, but it is the light weight volcanic tuff which becomes very loose and fine-grained when disturbed.

Both physical controls and revegetation were employed. Physical controls included earth berms, rock lined stilling basins, rock slope protection and asphalt dikes. Revegetation methods included brush layering with willows, hydroseeding, fiberglass roving protection, spreading topsoil, seed, and straw mulch, and placing commercial matting over seeded areas. It was the revegetation methods that were especially innovative and unproven in the eastern portion of California, particularly the brush layering.

The primary erosion-control target was a 125-foot high embankment, constructed in November 1976, of volcanic-tuff material taken from the adjoining cut. At the foot of this embankment is Rock Creek, which is an important recreational fishery and scenic resource, as well as a source of domestic water supply. Sedimentation of this stream has been occurring for several years due largely to the erosion of the existing highway embankment. The slope was originally designed to be 2:1, but was steepened to miss an archeological site, near the base of the embankment.

IN MONO COUNTY FROM 8.3 MILES NORTH
TO 9.9 MILES NORTH OF THE INYO COUNTY LINE,
ABOUT 13 MILES NORTH OF BISHOP

09-Mno-395-8.3/R9.9



Length of Work = 1.7 miles
Length of Major Construction = 1.6 miles

UPPER SHERWIN GRADE PROJECT

Figure 29

Rock Creek passes under the highway in a concrete box culvert through a smaller embankment. This culvert and fill were to be extended, and similar problems of erosion and sedimentation were expected at this location.

A 507-foot long earth berm about 2 feet high was constructed in October 1976, parallel to the base of the large fill at a cost of about $500. A notched spillway was constructed near the top of the berm to permit overflow during heavy runoff. The purpose of the berm is to provide a positive barrier to the sedimentation of Rock Creek if a failure should occur in any of the erosion control measures. The berm also traps sediments arriving via the downdrains, some of which collect sediment-laden water from natural channels on the opposite side of the highway. Sediment deposited behind this berm eventually may reach the level of the top of the berm, unless occasional cleanout is performed. This area was cleaned out in July 1978.

In August 1977, the earth berm was seeded and fertilized as shown in Table 33. This process was also used on the road slopes along with straw. A reinforced-paper matting was staked over the seeded berm. A total of 5,070 square feet of the matting were placed at a cost of $641 (Photos 62 and 63).

Six stilling basins were constructed at the outlets of downdrains. These rock-lined basins serve to dissipate hydraulic energy and prevent gullying at the outlets. Periodic cleanout may be necessary, but it should not be a problem since much of the water is relatively sediment-free runoff from the pavement. Rock work for these basins cost about $1,100.

TABLE 33

SEED AND FERTILIZER MIXTURE

UPPER SHERWIN GRADE

	Pounds/acre
Oryzopsis hymenoides (Indian ricegrass)	10
Agropyron tricophorum 'Luna' (Luna pubescent wheatgrass)	20
Agropyron cristatum (Fairway crested wheatgrass)	10
Bromus mollis 'Blando' (Blando brome)	10
Purshia tridentata (Bitterbrush)	2
Chrysothamnus nauseosus (Rabbitbrush)	2
	54

Fertilizer was 16-20-0 (Nitrogen-Phosphorus-Potassium) applied at 200 lbs/acre.

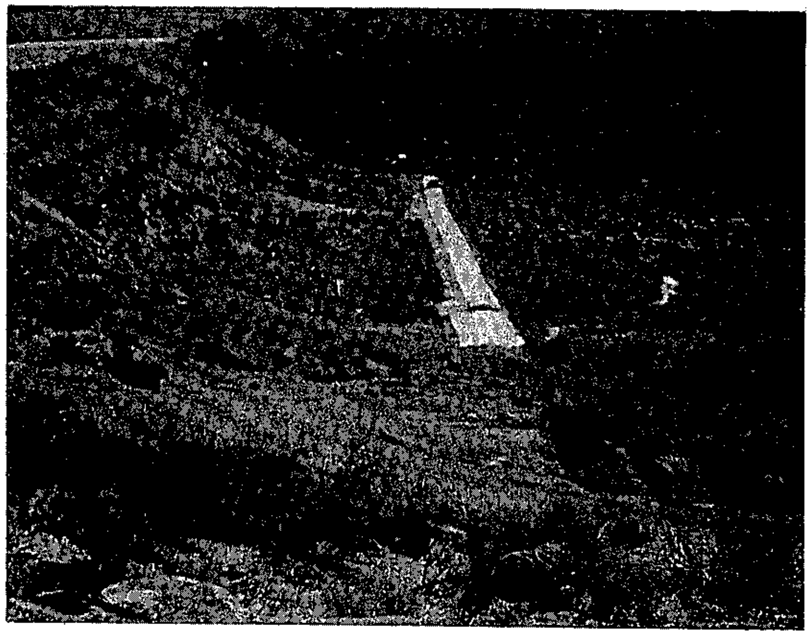


Photo 62

Earth Berm Covered with Erosion-Control Matting. August 1977

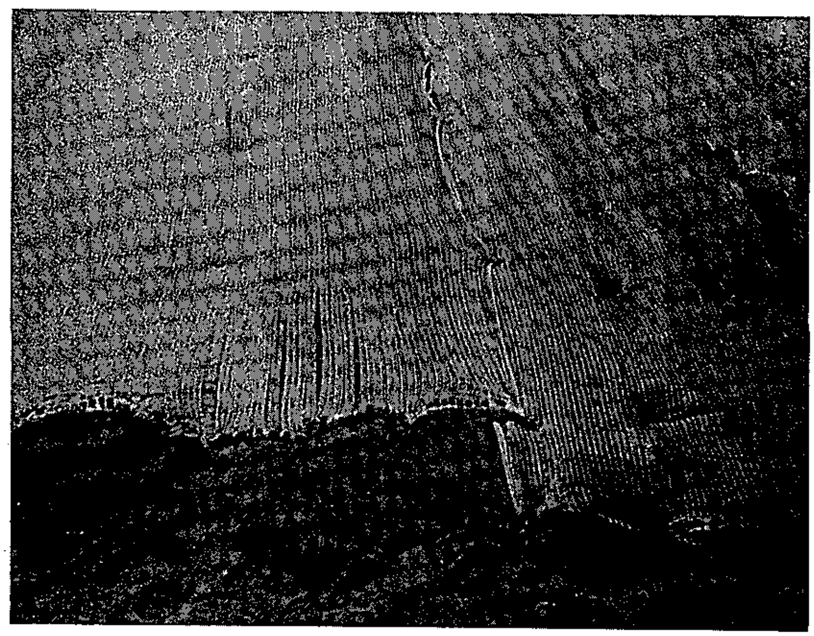


Photo 63

Close-up of Erosion-Control Reinforced Paper Matting. August 1977

Rock-slope protection was placed on the banks of Rock Creek where it emerges from the box culvert under the highway. Total cost was about $6,000.

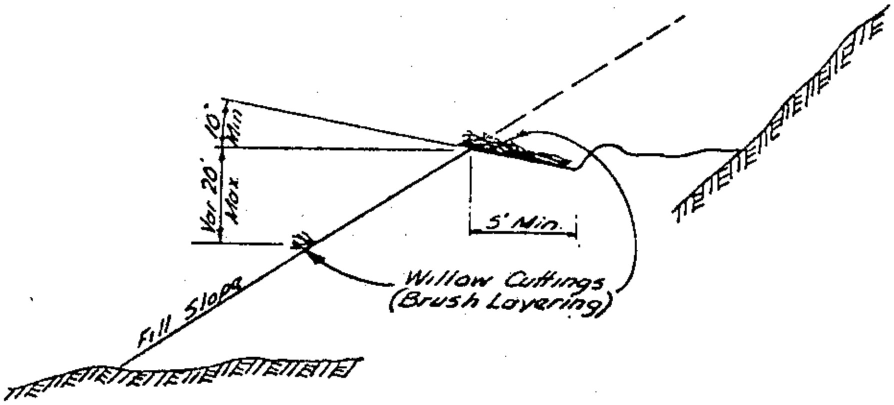
Asphalt dikes at the edge of pavement, and drop inlets and downdrains were installed by standard construction methods.

Brush Layering is a process of implanting willow cuttings into highway slopes. The brush layering process had earlier applications in California many years ago such as the Berkeley region of the Bay Area. Because its use is labor intensive, the high cost of installation resulted in decreased use of this technique over the past several years. TransLab revegetation research(20,21) in the Lake Tahoe Basin with the University of California at Davis and the U.S. Soil Conservation Service Lockeford Plant Materials Center, in the 1970's made use of willow wattling and brush layering techniques using conservation corps workers. This resulted in lower labor costs. As a result of successful installations, the technique was incorporated into the fill on the Upper Sherwin Grade Project in November 1976. On the Route 395 project, the brush layers consisted of willow (Salix var.) 5 feet long and about 1/2 inch in diameter. The willow branches were criss-crossed in a horizontal layer at about 6 branches per lineal foot. Fill was placed on top of each row and compacted. Another row of willow branches were placed about 10 feet above previous row and the process was repeated until the fill was topped out. Along the upper slope, fiberglass roving was specified to reduce the rilling effect that was experienced on the existing fill. Adherence to the Caltrans Standard Specification 7-1.01L was required. Figure 30 shows the location of the brush layering and

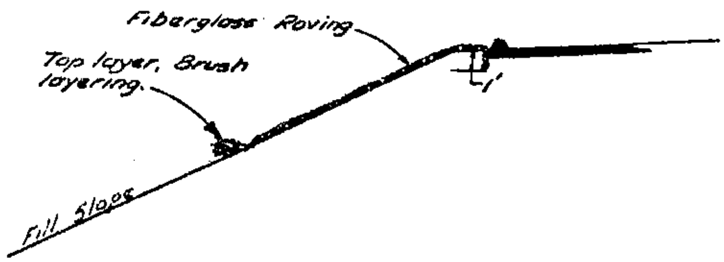
09	MNO	395	8.3/R9.9	15	22

PROJECT ENGINEER — REGISTERED CIVIL ENGINEER NO 16634

DATE APPROVED July 6, 1976



TYPICAL SECTION
BRUSH LAYERING



TYPICAL SECTION
ROVING

REDUCED PLAN
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

CONSTRUCTION DETAILS
BRUSH LAYERING & ROVING

Figure 30

fiberglass roving. With these mitigation measures, it was concluded that there would be little impact to Rock Creek.

The first layer of willow cuttings was taken from the abundance of willows along Rock Creek, within the construction limits. However, the U.S. Forest Service requested that no more willow be taken along Rock Creek. Therefore it was necessary to obtain willow cuttings from another source. Cuttings were taken from an area about 10 miles south of the project and at an elevation about 3,000 feet lower. The willows from on-site were keyed out as <u>Salix exigua</u>; the imported willows were identified as <u>S</u>. <u>hindsiana</u>, but this identification is uncertain. The contract specifications for brush layering were as follows:

> "10-1.14 BRUSH LAYERING.--Brush layering shall conform to the details shown on the plans and to these special provisions.
>
> Brush for brush layering shall be willow cuttings, at least 5 feet long and 1/2 inch or greater in diameter, that are native to the area. Cuttings shall be either fresh-cut or dormant cuttings that have been stored in a cool moist place.
>
> Willow cuttings shall be placed in the fill slope, butt end in, with the tops protruding from the slope at an angle of approximately 10 degrees above the horizontal. Cuttings shall be placed with the stems criss-crossing in the trench.
>
> Before covering the cuttings with embankment, the cuttings and the surrounding area shall be thoroughly wetted.
>
> The average number of willow cuttings to be placed in the trenches shall be not less than 6 per linear foot of brush layering.
>
> Willow cuttings for brush layering may be obtained from properties owned by the City of Los Angeles Department of Water and Power, Land Management Office, Independence, California."

Photo 64

Preparing Bench for Willow Cuttings
November 1976

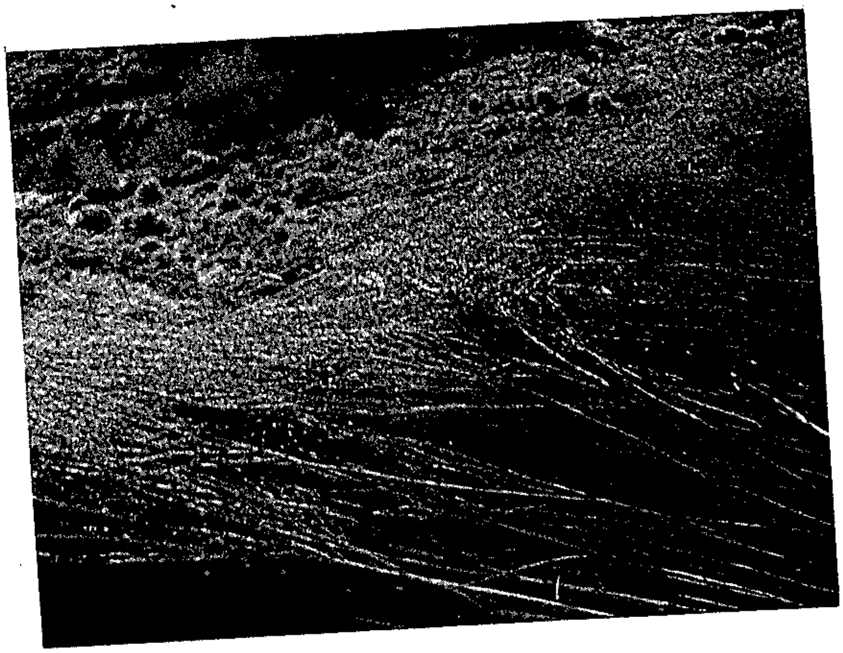


Photo 65

Willow Cuttings in Place
November 1976

The willow cuttings were cut in the fall near the beginning of their dormant season. The fill slopes bordering Rock Creek were being constructed at this time. As the fill slopes were brought up by lifts, a bench was created at the top of each lift. Willows were laid on these benches with their butt ends pointing in, and their branches extending out beyond the edge of the bench. A minimum of 6 willow cuttings per lineal foot was spread along the bench. The bench had been shaped previously so that the willows sloped up about 10 degrees above horizontal when placed. The willows and bench were thoroughly wetted and then buried by the succeeding lift of material. Only 1-2 feet of the willow branches were left sticking out of the earth to form a fence of cuttings across the face of the entire slope. This process was repeated at 10-15 foot vertical intervals as the slope was built. A total of 6 rows of willows was installed on the large fill slope, and 5 rows on the smaller slope over the box culvert. Total lineal feet of willow cuttings installed were 4,502 feet at a cost of about $4,500.

The brush layering proved to be very successful in terms of growth. At the beginning of the next growing season (spring 1977) the willow cuttings began to leaf out, and later new shoots began to sprout from the buried portions. The native willows taken from the banks of Rock Creek were very successful in budding and leafing on the exposed branches. The willow cuttings imported from the lower elevation did not leaf out, but later sent up new shoots from beneath the surface. About 90% of the willow cuttings eventually took root or sent up new shoots. It is expected that the willows will spread by underground runners to help fill the spaces between rows.

This method of vegetation may have wide application for future highway projects. The surfaces of the fill slopes on this project are dry and hot throughout the summer - not a typical willow environment. This procedure shows that willows can grow on some slopes that are normally considered too dry for willows.

Another advantage of this method is that immediate erosion control is obtained by the "fences" of willow cuttings. This eliminates the critical waiting period of one or several growing seasons which is often required of seeded slopes before effective control is established.

Photos 66 and 67 show the completed slope with the brush layering (willow sp.). A typical construction plan for the brush layering and fiberglass roving is shown in Figure 31.

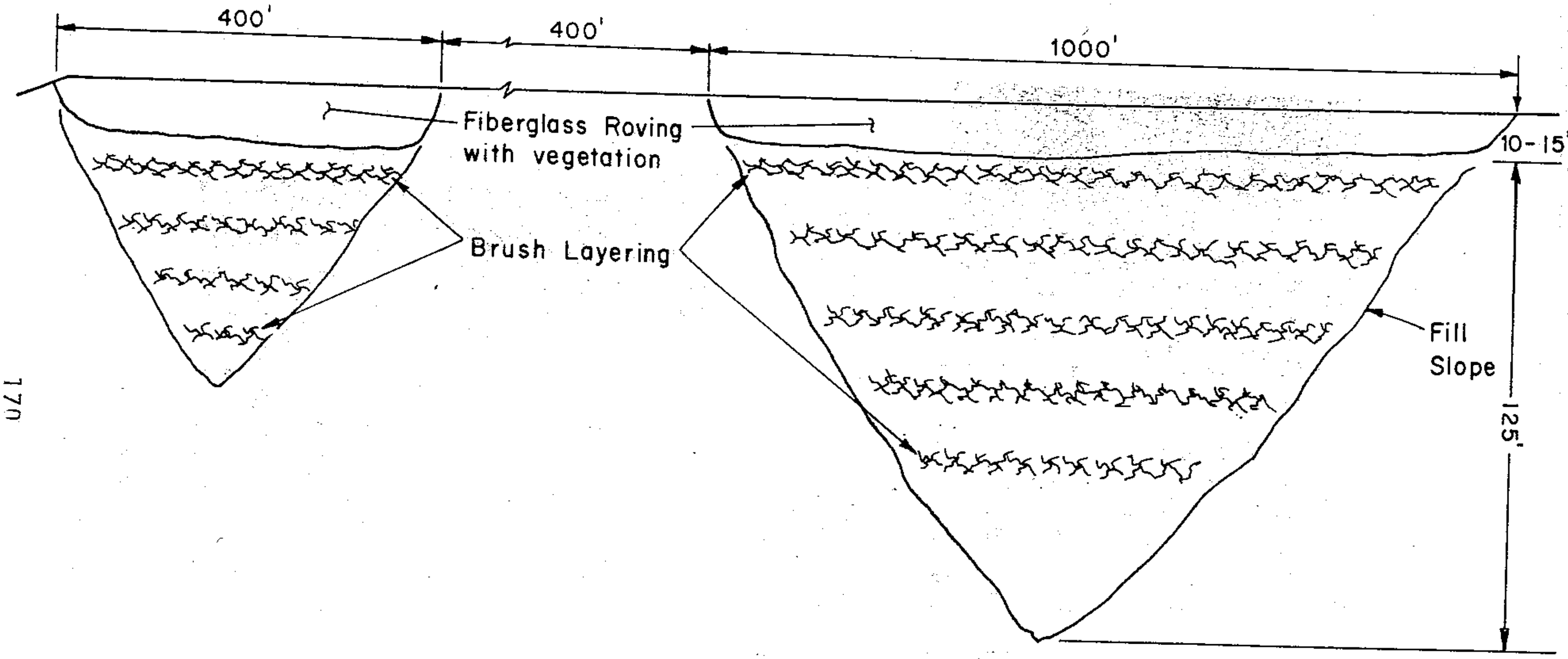
Fiberglass roving is a relatively new material developed to stabilize slopes and provide protection to newly seeded areas. Originally it was used to stabilize earth ditches that were subject to scour. Past experience has shown that the top portions of slopes are the most difficult to vegetate, probably because the seed is washed down to the lower portions of the slopes. Also this section of highway slope must be kept free of heavy brush due to fire hazard. Therefore, a strip which varies from 10 to 25 feet wide at the top of the fill slopes was chosen for hydroseeding with a grass seed mixture, and covering with fiberglass roving. Basically this was the remainder of the slope above the top row of willows (see Figure 31).

Photo 66

Large Fill Slope Showing Revegetation from Brush Layering & Duff Spreading Facing in Direction of Southbound Traffic. July 1977

Photo 67

Close-up of Willow Growth
July 1977



BRUSH LAYERING AND FIBERGLASS ROVING
UPPER SHERWIN GRADE
09-MONO-395, P.M. 9.0
$1\frac{1}{2}$:1 SLOPE
WEST FACING ASPECT

Figure 31

First the area was hydroseeded with a mixture of wheatgrasses, brome grasses, native Indian rice grass, bitterbrush, and rabbitbrush, plus fertilizer and wood fiber mulch. Fiberglass roving was air blown across the seeded area at a rate of between .29 and .41 pound per square yard. This produced a dense "cobweb" of white fiberglass strands blanketing the seeded area (see Photo 68). A total of 2,491 square yards of slope was covered at a cost of $2,500. An asphaltic emulsion was sprayed on the roving at a rate of .23 to .32 gallon per square yard (see Photo 69). The asphaltic emulsion serves as a binder to hold the roving in place. Cost of the emulsion was $618.

Finally, the upper edge of the roving/emulsion mat was buried in a narrow 1-foot deep trench along the top edge of the fill. This was done to anchor the roving mat so that it would not slip downhill. The digging of this trench proved to be the most time consuming and expensive task in the installation of the roving process. (This cost was borne by the contractor, and is included in the price paid for roving.) The entire trench was dug by hand since the asphalt dike at the edge of pavement and the guardrail along the top of the slope prohibited the use of mechanical-ditch diggers. For future roving projects, consideration should be given to digging this trench before other roadway features prevent the access of mechanical equipment. Also it was estimated that a trench 6 inches to 8 inches deep would have been sufficient. The roving was completed in late July of 1977 (see Photo 70).

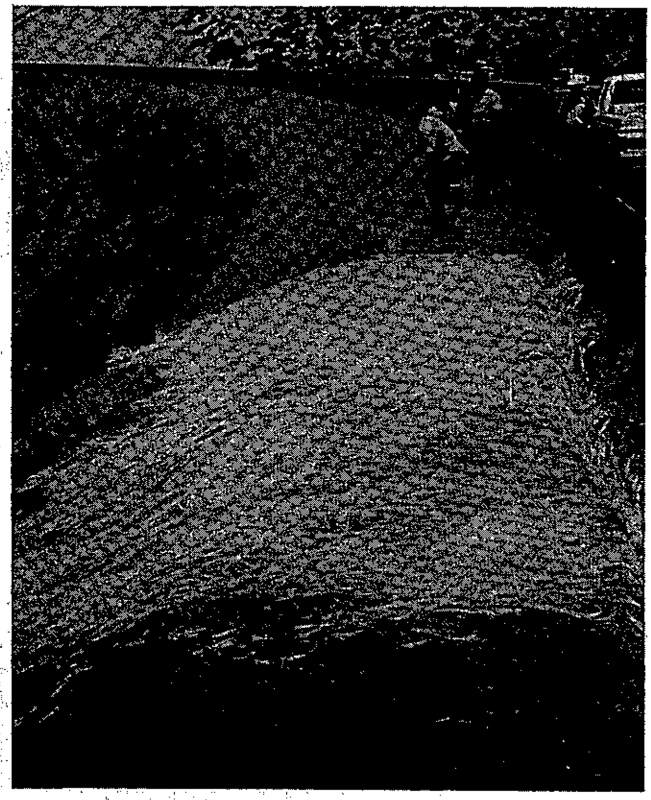


Photo 68

Applying Fiberglass Roving
July 1977

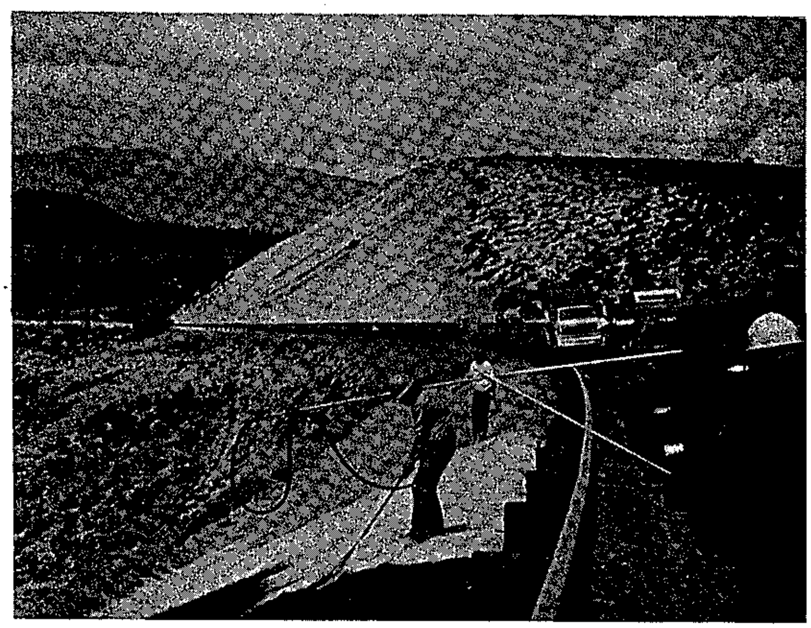


Photo 69

Applying Asphalt Emulsion to Roving
July 1977

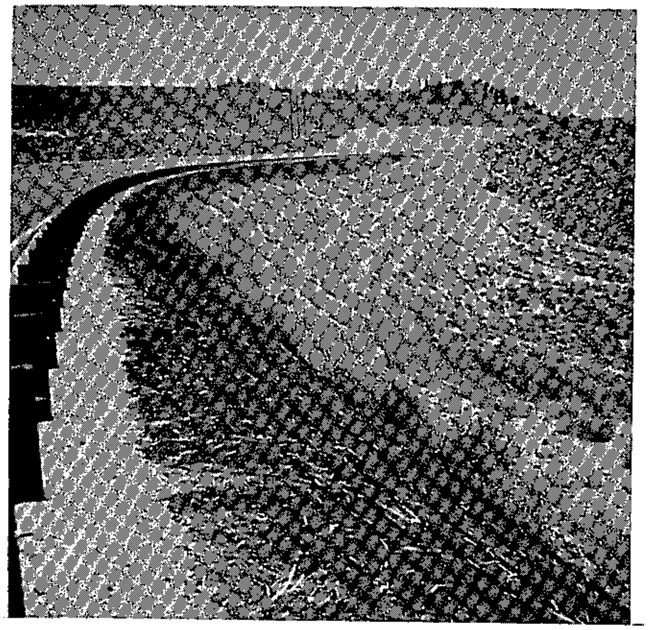


Photo 70

Overall View of Completed Slope
Summer 1977

The native topsoil and vegetation, which were removed during initial roadway excavation, were stockpiled and later spread on the surface of the fill slopes. The material was spread as the fill slopes were being constructed, just prior to the installation of the brush layering. The material was spread 6 inches deep over 11,360 square yards at a total cost of about $11,400.

Initial growth on the topsoil seems to be nearly all thistle and pigweed. Evidently these seeds are present in the surface soil and will sprout readily and grow when the soil is disturbed and there is no competition from native perennials. Although the thistle and pigweed are not desirable plants to encourage, they have provided good slope cover and stabilization. Eventually they should give way to more desirable native plants. A few perennial plants have begun to grow, especially the prickly poppy.

On all other fill slopes steeper than 4:1, straw was rolled into the soil with a tamping roller at a rate of 4.0 tons per acre. Then seed and fertilizer were spread by hydroseeding, using the same seed mixture as described in the hydroseeding-roving method. Nearly 3 acres of slopes were treated this way at a total cost of about $5,000.

Originally the two fill slopes that were described under brush layering, hydroseeding-roving, and duff topsoil were to receive the seed mixture and straw mulch between the willow rows. This was not done at the time of the brush layering or topsoil spreading, and later proved difficult to accomplish without doing considerable damage to the willow rows. The contractor asked for relief from this portion of the contract and it was granted. It is recommended that future contracts which contain revegetation methods that may be mutually interfering include a specific order of work. Alternatively, it may be desirable to have the contractor prepare a specific plan for accomplishment of the work and submit the plan in advance for approval.

It would also seem desirable to specify that vegetation items be accomplished concurrently with construction or at a specific time of year. Many times contractors leave vegetation items as one of the last items of work, thereby leaving new slopes exposed to erosion during the remainder of the construction period. This is especially significant if a winter postponement occurs after slopes are constructed, but before vegetation is accomplished. On this project, for example, only the brush layering was completed before winter suspension, and many essentially unprotected slopes were exposed to erosion for about 6 months.

The RCB extension for the Rock Creek crossing was accomplished by installing a barrier inside the existing box and piping the stream through the construction area. The discharge was below the planned realignment. Photo 71 shows the completed RCB outlet.

Riprap and gravel were placed along the channel to protect against scour and provide a fishery habitat. Willow cuttings were placed in the channel bank to provide habitat and vegetative shading from the hot afternoon sun during the summers.

Postconstruction Evaluation

Postconstruction monitoring was carried out by TransLab Water Quality Section at 5 locations as shown in Figure 32.

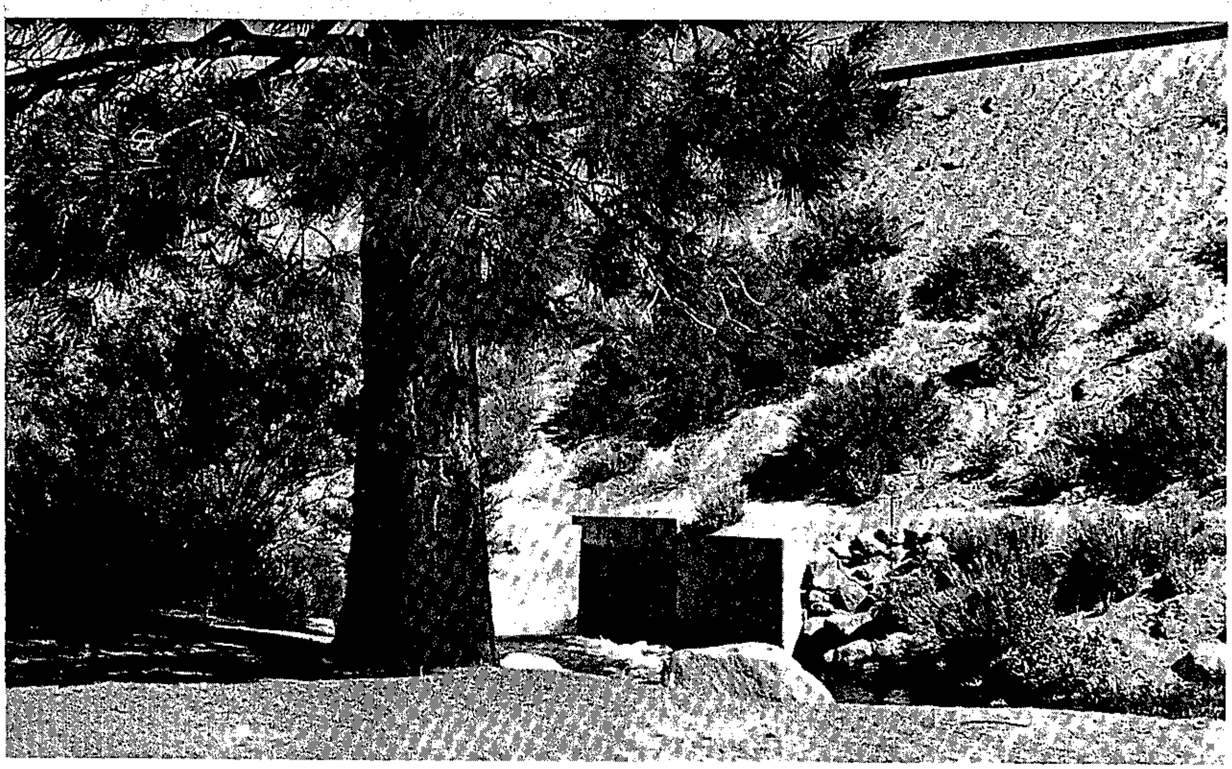
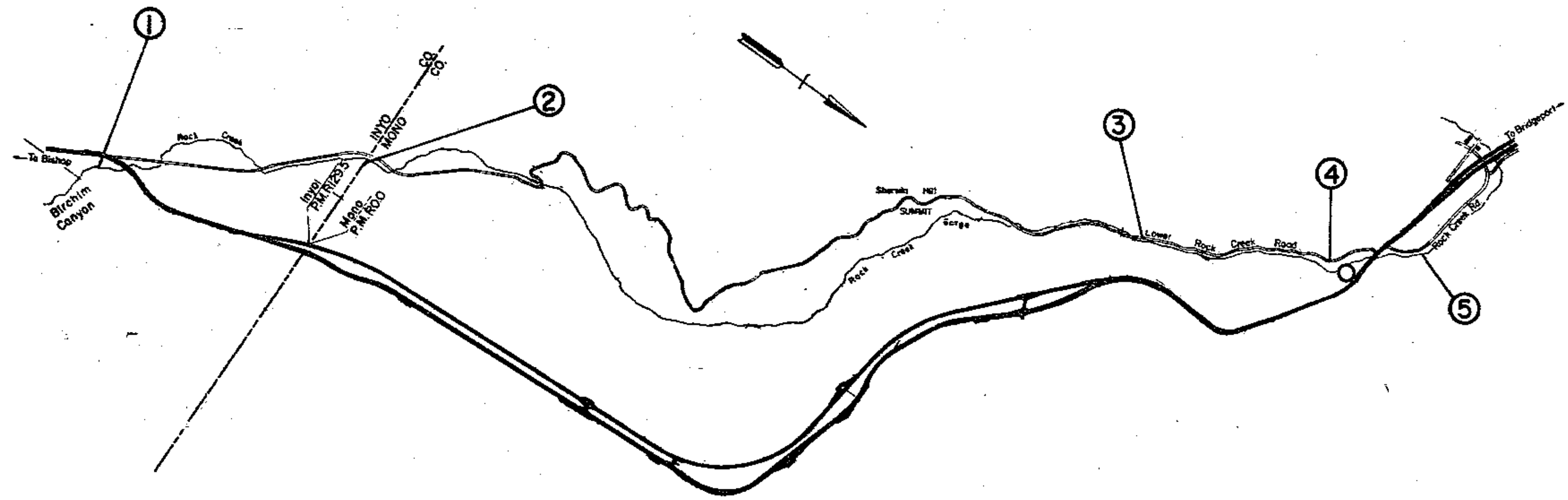


Photo 71
Outlet of Reinforced Concrete Box (Rock Creek)



Legend

② SAMPLING SITES

O PRECIPITATION GAGE

TRANSPORTATION LABORATORY AQUATIC BIOLOGY MONITORING LOCATIONS						
DATE	DIST.	COUNTY	ROUTE	POST MILE	DWG. NO.	TOTAL SHEETS
	09 09	INY MNO	395 395	127.7/129.4 0.0/9.5	657081	

Figure 32

Monitoring consisted of seasonal samples of macroinvertebrates (aquatic insects) in the stream bottom, temperature, dissolved oxygen, and turbidity (Photos 72 and 73). Table 34 shows the monitoring schedule.

Field data showed that water quality in Rock Creek located at the southern end of the project, has not been adversely affected by the highway project. The stream continues to maintain a high level of quality and exhibits numerous groups of cleanwater-aquatic organisms which are indicative of excellent water quality.

Although portions of Mill and Horton Creeks were realigned and portions of the streambanks lined with riprap, no adverse impacts probably occurred due to solar radiation because the existing streams had no or very little vegetative cover. No temperature measurements were recorded on Mill and Horton Creeks.

Station 1 lies approximately 150-300 feet below U.S. 395 at 09-Iny-395 PM 127.73 on Rock Creek at its confluence with Pine Creek. Substrate consisted of cobbles 3-8 inches in diameter, water depth 6-10 inches and relatively swift flow. Samples showed a fairly good diversity with Ephemeroptera (mayfly), Plecoptera (stonefly), and Tricoptera (caddisfly) predominating. There were also large numbers of Simuliidae (black flies) which should be expected since the area supports a number of cattle.

This station which lies below the project shows no signs of sedimentation or any other impacts associated with the construction. It appears the extra environmental measures taken during construction have paid off very well.

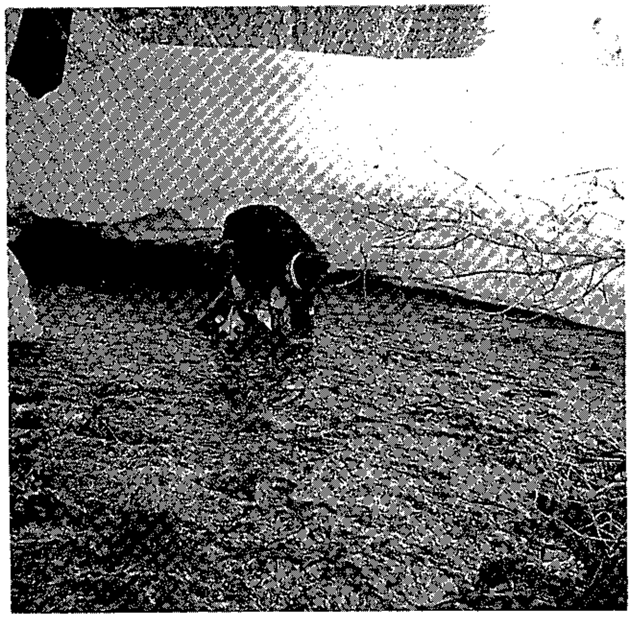


Photo 72

Biologist Collecting Aquatic Macroin-
vertebrate from Rock Creek (Site 3)
March 1978

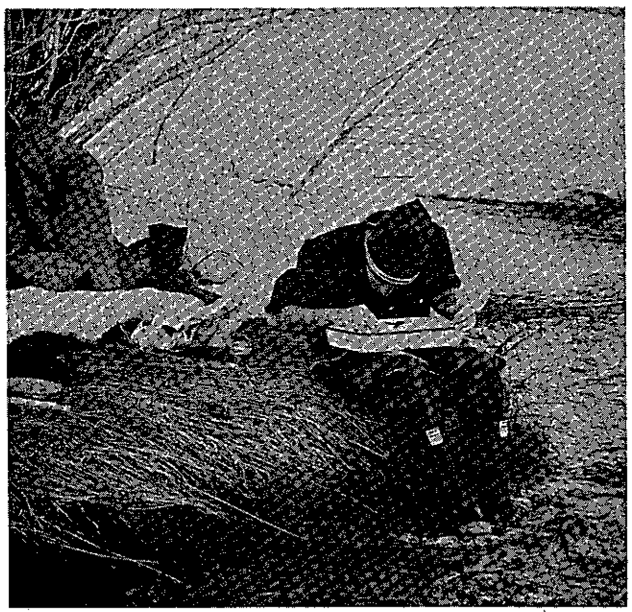


Photo 73

On-Site Sorting of the Macroinvertebrates

TABLE 34

SAMPLING AND TESTING SCHEDULE
(APRIL 1977 TO APRIL 1978)

Rock Creek

Item	Test Method	Location	Frequency
Macroinvertebrates		1,2,3,4 & 5	Quarterly
Temperature	Calif. 734	"	Quarterly
Dissolved Oxygen	Calif. 733	"	Quarterly
Turbidity	Calif. 731	3,4,5	During 4 or 5 storms

Note: D.O. Taken between 0800-0900 hours.

Station 2 was located at the Inyo/Mono County line on Old Highway 395. The stream is approximately 60 feet from the road and approximately 3 miles upstream from Station 1. A second study site closer to Station 1 was not possible because the intervening stream is meandering and slow which would not be comparable to the rocky substrate of Station 1.

Station 2 also showed very good diversity with numerous species of mayflies, caddisflies and stoneflies. Stoneflies were especially prevalent, and a relatively rare family, Peltoperlidae, was found. There were noticeable fewer Simuliidae present.

Three additional stations were sampled on the upper terminus of Sherwin Grade Project. Station 3 was located approximately 600 yards below the crossing of Rock Creek and U.S. 395 and approximately 300 yards below the brush layering fill on the Sherwin Grade. Station 4 was in the portion of Rock Creek which is directly below the highway fill. Station 5 was taken above the U.S. 395 crossing of Rock Creek and above the intake pumps for construction.

All three of these stations showed very good diversity with many species of Ephemeroptera (probably 6-10 species), Plecoptera, again Peltoperlidae as well as numerous other families, and substantial Tricoptera representatives. There was also a noticeable lack of black fly larvae in these samples.

No scouring of banks is evident along the stream channel. Vegetation has been reestablished along the channel banks and the realigned portion blends in well with the existing channel downstream.

The highway cut slopes along the Sherwin Grade project (middle project) and Round Valley project (lower end) did not revegetate as planned. The projects were seeded with Atriplex canascens (Fourwing saltbush), Stipa specison (Desert needle grass), Oryzopsis hymenoides (Indian rice grass), and Chrysothamnus mohavensis nauseosus (Rabbit brush). No fertilizer was used on the project.

Lack of growth is attributed to the arid high desert environment. The environment along this stretch of road is not conducive to extensive vegetative growth.

Soil samples were taken at two locations on the Sherwin Grade project in the fall of 1977 to test for soil pH and the presence of nutrients. The testing was accomplished in accordance with a TransLab study on the use of a soil nutrient test kit for specifying fertilizers(34). Results of the tests are shown in Table 35.

TABLE 35
SOIL NUTRIENT TEST RESULTS

	Sample 1	Sample 2	Nutrient Needed
pH	8.3	7.8	*
P	35 lbs/acre	25 lbs/acre	100 lbs/acre
K	380 lbs/acre	790 lbs/acre	250 lbs/acre
NH_4	70 lbs/acre	35 lbs/acre	120 lbs/acre
NO_3	7 lbs/acre	5 lbs/acre	

*A pH range of near 7.0 (neutral) is most conducive to plant growth.

It appears from the test results that there is a substantial need of Phosphorus (P) and Nitrogen (NH_4 and NO_3) on the slopes. This may account for the lack of vegetative growth. Should these slopes be seeded in the future, appropriate fertilizer containing these ingredients, spread at the rate needed to meet the nutrient deficiencies, should be required.

In August 1974, 93 acres of slope were reseeded. Three of the slopes were scarified and 3 were not. The seed was applied as follows:

Seed	lbs/acre
Standard crested wheatgrass (Agropyron cristatum)	13.8
Blando bromegrass (Bromus mollis)	10.6
Indian rice grass (Oryzopsis nymenoides)	2.3
Saltbush (Atriplex Sp)	1.9
Antelope bitter brush (Purshia tridentata)	1.7

In June 1975 the six slopes on Sherwin Grade were inspected for plant germination. There was some growth of Soft chess (Bromus mollis) but not enough to reseed. Some Downy chess (Bromus tectorum) was growing at the upper end but it looks as though it is invading. Saltbush (Atriplex) is also invading.

The plants that were put out are doing very poorly. Only 18 were found alive and 26 were dead, but some of these were hard to find. The rabbits are eating the 18 that remain.

It looks as though there is no difference between slopes that were ripped or not ripped. There was not enough moisture to germinate any more seed.

The brush layering with willows on the Upper Sherwin Grade project had limited success in preventing slope erosion. However, the willows have rooted and are growing. During the 1977-78 winter, there was an unusually heavy snowfall. Table 36 shows the precipitation (rain and snow) and moisture content of the snow pack.

The unusually deep snow cover coupled with warming temperatures brought about a rapid snowmelt. The heavy moisture on the loose soil resulted in a mud flow on February 2 and 3, 1978 (See Photos 74 and 75). The flow washed sediment down the slope and onto the top of the snow at the base of the slope. All the sediment was trapped behind the berm, however, and there was no adverse impact to Rock Creek. A biological survey of the stream revealed no influence due to the sudden washoff of soil.

The brush layering did provide a reinforcement to the slope. However, because the willow was placed perpendicular to the slope face there was no capability for trapping significant amounts of sediment. A horizontally placed row of willow wattling may have been effective in trapping sediment.

The brush layering did enhance the growth of native weeds by providing a wind-break and a catchment. The willows grew significantly and in time will provide a good cover. The area of the fiberglass-roving mat has some grass cover and appears to be stabilizing the upper portion of the

TABLE 36
PRECIPITATION RECORD
UPPER SHERWIN GRADE

Date	Snow	Moisture	Snow on Ground
8/20/77	(rain)	0.42"	
8/21	"	0.12"	
10/6	"	0.06"	
11/21	"	0.05"	
11/22	2"	0.12"	
12/17	2"	0.21"	
12/18	15"	2.10"	16"
12/19	Trace		16"
2/22	11"	0.86"	25"
12/23	6"	0.46"	31"
12/24	8"	0.55"	39"
12/27	3"	0.47"	40"
12/28	3"	0.30"	43"
1/5/78	2"	0.16"	30"
1/6	3"	0.38"	32"
1/10	6"	0.50"	28"
1/15	8"	0.98"	33"
1/16	1"	0.06"	33"
1/17	20"	2.20"	50"
1/19	1"	0.07"	50"
1/26	-	-	33"
2/5	2"	0.25"	31"
2/6	2"	0.47"	31"

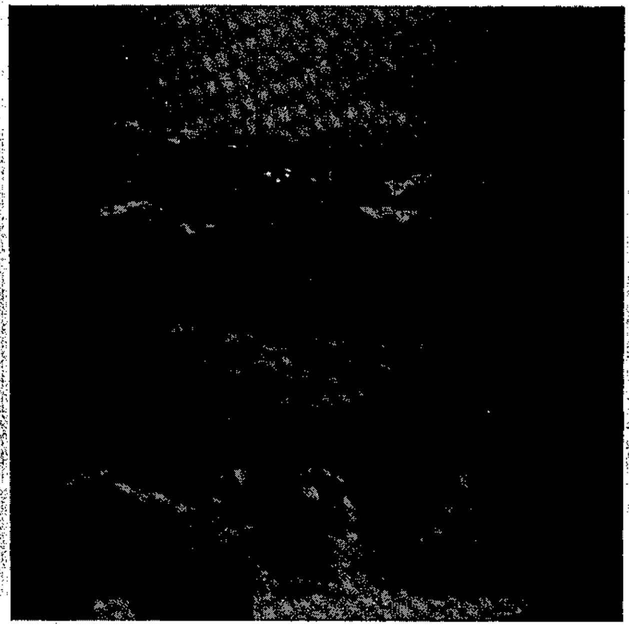


Photo 74

Severe Slope Erosion as a Result of
Rapid Snow Melt (Upper Sherwin Grade)

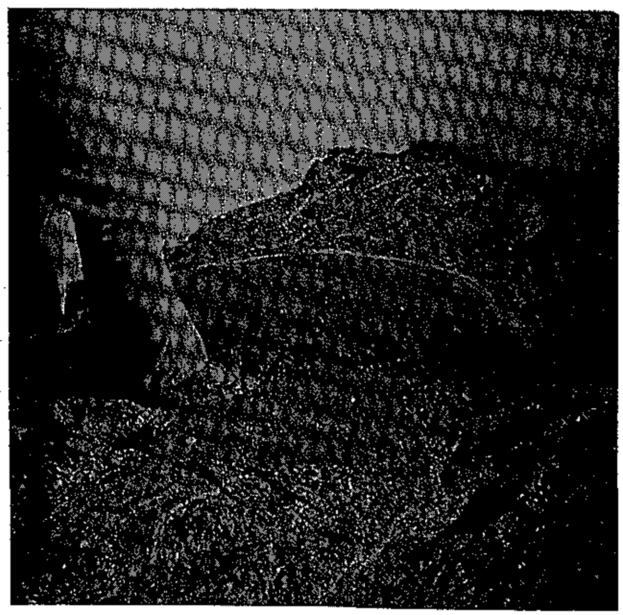


Photo 75

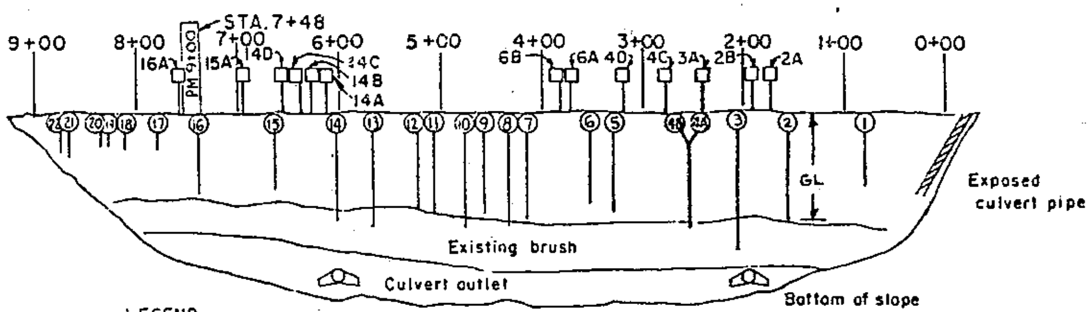
Close-up Showing Saturated Soil
Resulting in Severe Erosion

slope above the crest where the slope is fairly flat. Below the crest of the slope, the mat has been undermined by gullying. The gullies were mostly formed during the rapid snowmelt that occurred.

The fiberglass-roving mat was rolled up in a few places by tumbleweeds that had blown up the fill slope and been caught under the mat, primarily in the gully areas. It is possible that this could be prevented by anchoring the lower end of the mat in a trench similar to that used for holding the upper end on the slope.

Both the Lahontan Regional Water Quality Control Board and U.S. Forest Service have requested Caltrans to undertake remedial work to protect Rock Creek. District 09 and TransLab developed a willow wattling plan to place checks in various gullies to retard further erosion.

Figure 33 shows the wattling plan. The willow wattling was placed by California Conservation Corps employees during April 1979. Other corrective action taken by District 09 consisted of making repairs to the earth berm where some minor washing occurred, installing a sand bag catch basin and two filter fences at the low point in the berm to allow overflow water to deposit sediment before reaching Rock Creek, and planting 115 plants from 4 inch nursery pots along the base of the slope (Atriplex canescens, Atriplex lentiformes, Pursia glandulosa, Cowina mexicana, Atriplex confertifolia, and other miscellaneous species). Photos 76 and 77 show the willow wattling and silt fence. Biological monitoring continued through June 1979 along Rock Creek as part of a TransLab water-quality study to ascertain if any impacts are occurring (35). No adverse effects have been detected.



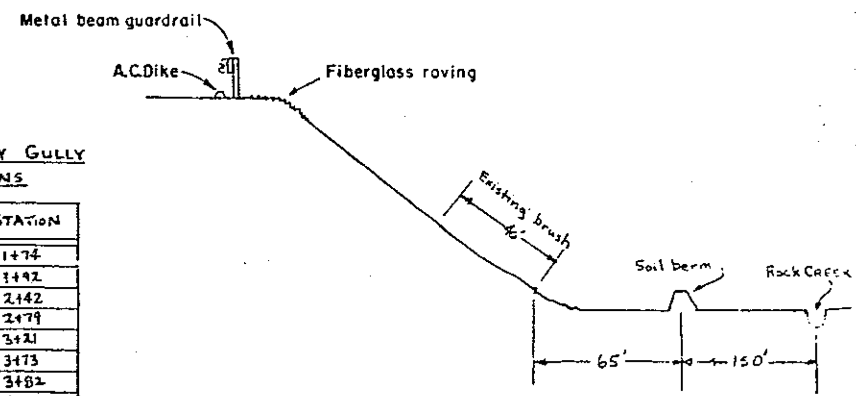
NOTES

- Station 0+00 is located at the southern end of the metal beam guardrail.
- Primary gullies are staked at the top of the slope.

LEGEND

○ PRIMARY GULLY LOCATIONS
□ SECONDARY GULLY LOCATIONS
▯ EXISTING POST MILE PADDLE
GL PRIMARY GULLY LENGTH

ELEVATION VIEW
NO SCALE



SIDE ELEVATION VIEW
NO SCALE

PRIMARY GULLY LOCATIONS

GULLY NUMBER	STATION	LENGTH-GL ft	SLOPE ANGLE, DEGREES
1	0+81	72	35
2	1+54	100	34
3	2+04	130	35
4A	2+47	112	35
4B	2+61	112	35
5	3+36	95	34
6	3+52	88	35
7	4+17	100	37
8	4+31	108	35
9	4+57	95	37
10	4+77	109	37
11	5+07	98	36
12	5+20	93	36
13	5+68	109	35
14	6+03	101	36
15	6+66	72	36
16	7+37	76	36
17	7+89	37	34
18	8+12	33	32
19	8+29	30	32
20	8+35	31	32
21	8+68	43	32
22	8+15	39	32

SECONDARY GULLY LOCATIONS

GULLY NUMBER	STATION
2A	1+74
2B	1+92
3A	2+42
4C	2+79
4D	3+21
6A	3+73
6B	3+82
14A	6+12
14B	6+28
14C	6+36
14D	6+56
15A	6+96
16A	7+57

INDEX MAP OF GULLY LOCATIONS

UPPER SHERWIN GRADE FILL SLOPE
09-Mno-395, PM 9.0

NOTE: Primary gullies are individually mapped on separate sheets showing recommended location of each willow wattling bundle used for erosion control.

4/79

Figure 33

Two photos of willow wattling installation and silt fence installed in May 1979. Upper Sherwin Grade.

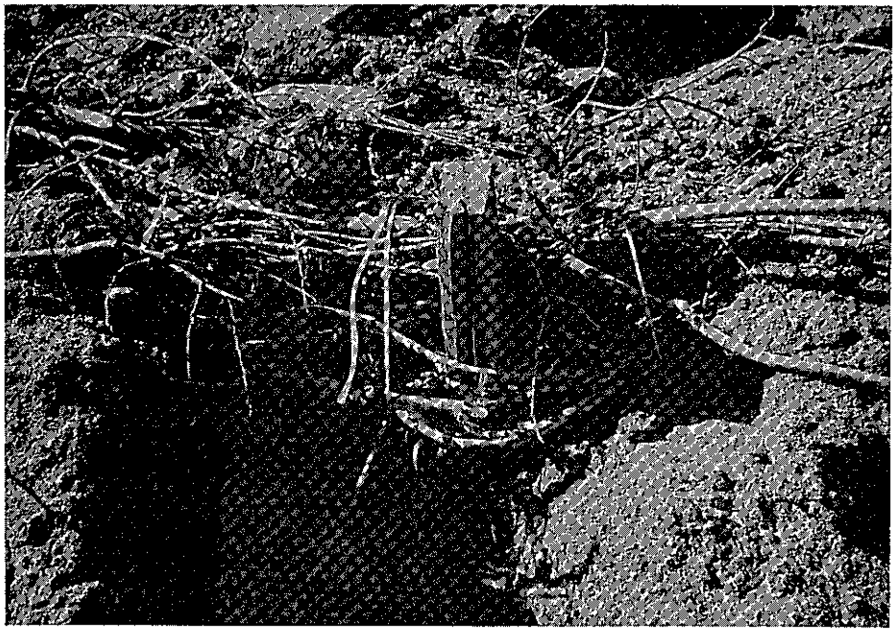


Photo 76

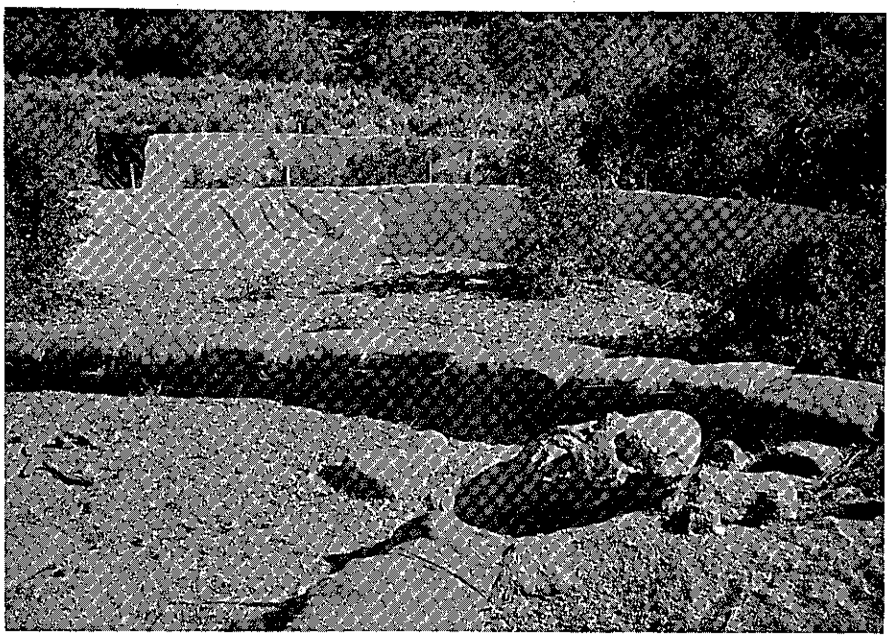


Photo 77

Summary

The Final Environmental Impact Statement for the three construction projects in Inyo and Mono Counties on Route 395 from 0.5 mile south to 10 miles north of the Inyo-Mono County Line was submitted October 1, 1971, and approved. This was one of the earliest EIS's submitted by Caltrans since passage of the National Environmental Policy Act of 1969. It also represented one of the first documents to consider technical water quality factors prior to formalized training of district personnel in these matters and publication of Caltrans instructions for water-quality studies. The FEIS called for water-quality-field studies to be undertaken prior to construction(30).

The District 09 Environmental Unit in the Materials Department did undertake comprehensive field testing of water quality in Rock, Pine, Horton and Mill Creeks after the FEIS was approved. The technical water-quality study was coordinated with TransLab and was successful in identifying existing water quality for the purpose of monitoring to discover adverse impacts during and after construction.

The technical-water-quality study identified potential impacts on Rock Creek at the lower project in Round Valley and in the upper project at Upper Sherwin Grade. This information proved to be very useful in the ensuing meetings with the Lahontan Regional Water Quality Control Board staff. The Lahontan RWQCB issued very stringent water-quality discharge requirements for the project because of the existing high quality of water in Rock Creek. The District 09 Environmental Unit was able to assist the construction department in the inspection and monitoring of water quality to the satisfaction of the Lahontan RWQCB.

Further aquatic-biology surveys by TransLab confirmed the high degree of success in protecting the streams from any long-term adverse effects as a result of the construction. Short-term impacts were limited to the stream diversions at the Route 395 crossing.

The major problem in the 3 construction projects on Route 395 was centered on the large embankment near Post Mile 9 in Mono County on the Upper Sherwin Grade job. Although the slope is undergoing erosion due to the soft soil that results in mudflows when highly saturated, the construction of an earth berm near the toe of the slope was successful in trapping eroded sediments and preventing their discharge into Rock Creek. The mudflow-erosion problem was not anticipated during preconstruction erosion surveys. Erosion was expected, however, and the extensive mitigation measures of placing willow-brush layers on the slope and fiberglass roving on the top of the slope were specified.

Slopes on the Sherwin Grade and Round Valley jobs failed to have a good vegetative cover although they were seeded and mulched. This probably was due to the arid nature of the area although subsequent soil samples showed a definite lack of nutrients in the soil. No fertilizer was used with seed on these two projects. The Upper Sherwin Grade project did include fertilizer along with seed, straw, and topsoil. Vegetation on the upper job was much more successful.

The monitoring of macroinvertebrates (aquatic organisms) above and below the project provided very valuable information for interpreting water-quality data and assessing impacts. This was not a part of the District-water-quality survey but was undertaken as part of the research for this project. Future projects of a similar nature would benefit greatly from biological surveys of this type.

Problems associated with the lack of vegetative growth on road slopes could perhaps be overcome by establishing vegetative experimental plots for 1 to 2 years during or following construction. Then successful treatments could be specified for the slopes on the project. In the interim, sediment basins and berms could be used to trap and direct sediment. In all cases, it appears that a soil analysis to identify nutrient deficiencies would be helpful. Then fertilizer could be specified based on the nutrient needs. TransLab has a soil test kit that could be used for this purpose.

The use of a District Environmental Unit inspector to monitor water quality and coordinate with the Lahontan RWQCB was very successful. Future projects should also use trained personnel for this purpose. Coordination with TransLab on technical-water-quality matters was beneficial and helped in dealing with the regulatory agencies.

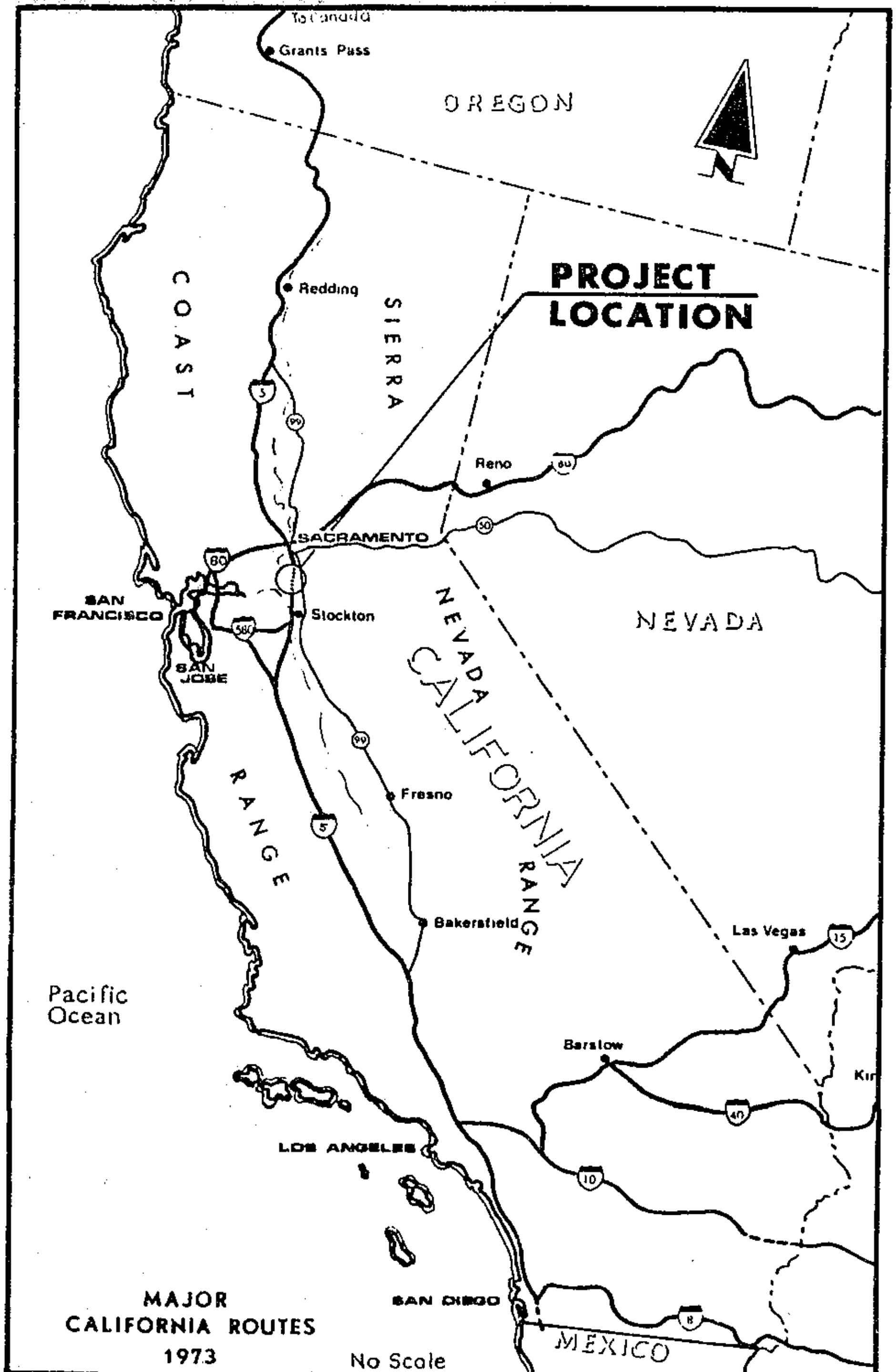
INTERSTATE 5, SACRAMENTO COUNTY (MOKELUMNE RIVER)

The I-5 project in south Sacramento County consists of new construction of a 4-lane divided freeway from the San Joaquin-Sacramento County Line to Lambert Road located 4.6 miles to the north. Interstate 5 traverses the entire length of California covering about 800 miles from Mexico to Oregon. The total length of I-5 from Mexico to Canada is in excess of 1,400 miles. The proposed 5-mile construction project is the last "gap" to be closed on the I-5 route. Figure 34 shows the project location.

The proposed project lies within the flood plain of the Mokelumne River. The climate of this area is mediterranean with cool wet winters and hot summers. Elevations are at, or near, sea level. As a result, the watercourses are all influenced by tidal action.

The land in this area is largely agricultural. The rivers and sloughs provide recreation and fishery resources. The three principal watercourses associated with the project are the Mokelumne River, Middle Slough, and Lost Slough. The Mokelumne River has salmon and steelhead runs. In addition, catfish, perch and small and large mouth bass are found in these delta waters.

The proposed Peripheral Canal's centerline is located about 0.5 mile to the west of the I-5 alignment. The Peripheral Canal is a part of the California Water Project designed to carry northern California's freshwater around the Delta and discharge it into the California Aqueduct located on the southern periphery of the Delta for use in the San Joaquin Valley and Southern California. At the time of this report,



I-5 SACRAMENTO COUNTY PROJECT LOCATION

FIGURE 34

approval for construction of the Peripheral Canal had not been given.

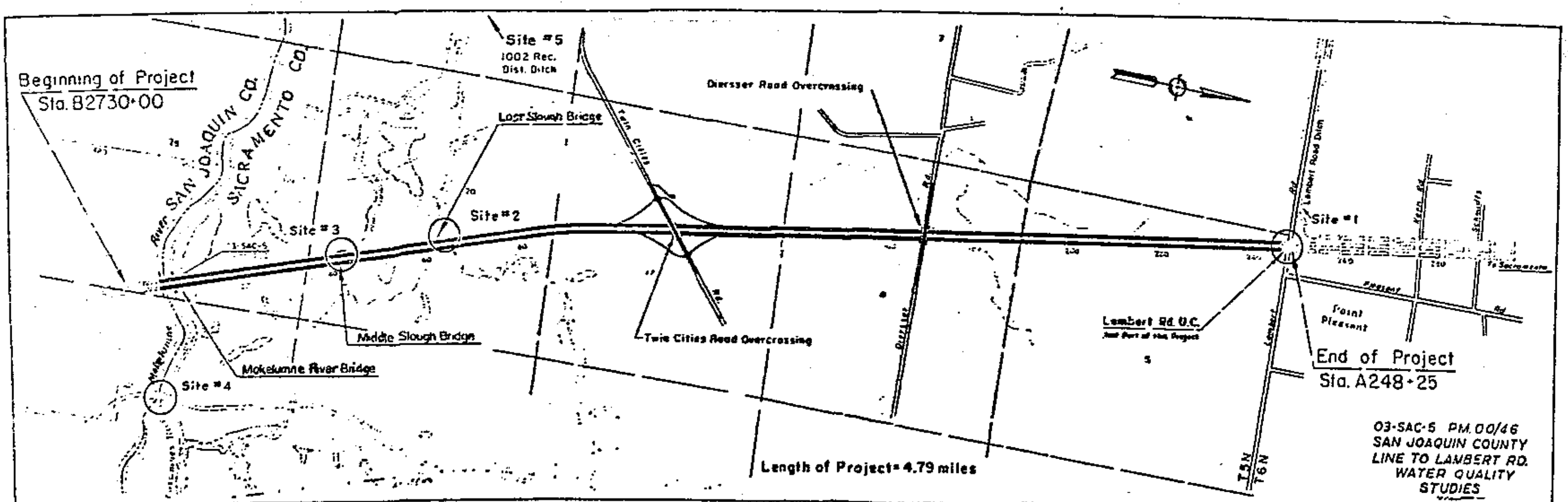
Three areas along the proposed canal were selected to provide soil for use as embankment for the I-5 freeway. The material sites are planned to be used as recreation sites by the Department of Water Resources until such time as the canal is built.

The District 03 Environmental Branch performed an environmental investigation and prepared an Environmental Impact Statement for the project in 1975(36). The technical study represented input from Caltrans 4-1/2 day training sessions on Water Quality Studies and publications presenting guidelines for technical studies and data analysis(8,9,10,11).

Environmental Study (Preconstruction)

The District 03 Environmental Branch Water Quality Unit performed a very comprehensive water-quality study on the proposed project for the EIS in 1973(37). The study included the collection and analysis of data obtained by other agencies including the Department of Water Resources, U.S. Bureau of Reclamation, and the U.S. Army Corps of Engineers(38,39). In addition, District 03 established 5 water-quality monitoring sites to develop additional background water-quality data to use in assessing potential impacts and in designing mitigation measures (see Figure 35). The Water Quality Basin Plan developed by the Central Valley Regional Water Quality Control Board was used to assess potential impacts(40).

The following information on the background water quality of the Mokelumne River, is taken from the District 03 Water Quality Report(37).



WATER–QUALITY MONITORING SITES

Figure 35

"<u>Dissolved Oxygen</u>

The dissolved oxygen levels followed a seasonal pattern generally, with higher values in the winter and lower values in the summer. Dissolved oxygen remained near saturation most of the time, with the saturation level changing with the seasonal temperature change (see Table 1 and Fig. 1). The 24-Hr. dissolved oxygen fluctuation had a maximum 0.7 mg/L sag.

A healthy unpolluted aquatic environment in which algae populations are not excessive, is usually characterized by a near-saturated dissolved oxygen level with a maximum diurnal fluctuation of 1 to 3 mg/L.

<u>Biochemical Oxygen Demand</u>

Biochemical oxygen demand is used to quantify the amount of dissolved oxygen in mg/L that is required by aquatic organisms and for the aerobic biochemical decomposition of organic matter in water. The five-day BOD test is normally applied to sewage and polluted waters where the expected BOD values are high (50-300 mg/L).

The results of the five-day BOD test were quite low, with a mean value of 0.98 mg/L.

<u>pH</u>

The pH values for the Mokelumne River ranged from 6.7 to 8.0 with the mean value of 7.3. These pH levels are normal for estuarine type waters.

<u>Nutrients</u>

Nutrients are elements or compounds essential as raw materials for organism growth and development. One of the prime indicators for nutrient enrichment is total nitrogen concentration, which is the sum of organic and inorganic nitrogen.

During the period of study the total nitrogen concentration of the Mokelumne River never exceeded the State standard maximum of 3.0 mg/L and the mean concentration was equal to 0.44 mg/L.

Total Dissolved Solids

The sum of all dissolved constituents in water is commonly known as the total dissolved solids (TDS), the mean concentration for TDS was 73 mg/L, which is below the maximum allowable limits for water used for agricultural, domestic or industrial purposes.

Turbidity

Turbidity measurements ranged from 1.5 to 100 Formazine Turbidity Units (F.T.U.), and never exceeded the maximum limit of 150 units during the study.

The wide range of turbidity units measured is indicative of the seasonal rainfall and runoff, with higher values in the winter and lower values in the summer. Since the lower values can be expected during the summer, any construction in the main channel should coincide with the California Department of Fish and Game recommendations, so as not to interfere with the migrations of the anadromous fish.

Heavy Metals, Toxic Substances and Boron

Cadmium, chromium, copper, iron, lead, manganese and zinc, chlorinated hydrocarbon pesticides, radioactivity analysis and boron were measured to determine the general background levels. Concentrations of these constituents are varied and at times exceed the State standard, particularly with regard to heavy metals.

Evaluation Summary

Generally speaking, the quality of the surface water in the Mokelumne River is good. The chemical analyses, performed since 1967, on the many parameters listed in the following tables and graphs, furnished the valuable background data on the ambient conditions, which is required to make any valid evaluation. This historical data provided the necessary information to establish the seasonal variations.

During this period the water was found to be Class I (excellent to good) irrigation water with respect to all parameters listed in the California State Water Resources Control Board publication, "Water Quality Criteria".

The Mokelumne River can be considered acceptable for most forms of recreation with the possible exception of body-contact activities. The reason for this statement is that an in-depth analysis of the bacteriological quality of the Mokelumne River is not available at this time. Preliminary data indicates a borderline condition in that the fecal coliform counts of 230 MPN/100 mls is above the State standard of 200 MPN/100 mls. Since the results of only two tests are available to date, a valid statement about the sanitary condition of the Mokelumne River cannot be made at this time.

The fishery habitat conditions were found to be favorable, with dissolved oxygen levels near saturation most of the time. Utilizing some of the other primary parameters, such as pH, temperature, specific conductance, and ammonia, their measurements were all found to be within the acceptable limits.

In other words, with some exceptions, notably heavy metals, the water quality of the Mokelumne River meets the objectives of the "Water Quality Management Plan" of the California Regional Water Quality Control Board, Central Valley Region."

The district FEIS contained the following information relative to the watercourses and biological environment.

"Although the area between the Mokelumne River and the north bank of Lost Slough is considered a flood or overflow area, the large upstream storage basin reduces considerably the peak flow under the freeway bridges, and an open causeway type structure is not necessary.

The bridges have been designed to pass a flood stage of elevation 19.0 feet above mean sea level. The maximum stage recorded in this flood plain occurred in 1955 at elevation 18.5 feet above mean sea level.

The proposed highway embankment within the flood plain will decrease the existing waterway, increase the velocity at the proposed bridges and create a backwater head of about 0.13 foot just upstream from the proposed highway. The new highwater slope will meet the normal high-water at about 100 feet downstream from the proposed highway. Therefore, Caltrans feels that the effect of the highway embankment on the headwater elevation is, for all practical purposes, insignificant.

The bottoms of the bridge spans at Lost Slough and Middle Slough will be at elevation 21.0 feet, thereby providing 2 feet of drift clearance above the design flood stage. At the Mokelumne River crossing, the clearance above design stage will be 6.2 feet at the navigational channel and tapering to 3.3 feet clearance at the northerly end of the bridge.

The piers supporting the three crossings in the overflow area are at 60-foot centers, with the exception of the two supporting spans over the navigational channel of the Mokelumne River which provide a clear width of 88 feet. This exceeds the required minimum width of 65 feet. The bridge location and span lengths were approved by the U.S. Corps of Engineers by issuance of a bridge permit on November 28, 1966. An extension of time for this permit was granted by the U.S. Coast Guard, it expired on November 28, 1974. A permit will be obtained from the U.S. Coast Guard when the Final Environmental Impact Statement has been approved.

The Department of Fish and Game has reviewed the proposed project. They have recommended July 1 to September 15 as the desirable time of year that work should be done in the Mokelumne River area, so as not to interfere with the migrating of salmon, steelhead, shad, and striped bass. The bridge pier construction will require more time than the 2-1/2 month period recommended by the Department of Fish and Game. The additional time needed is for pile operations which Caltrans feels would have a relatively minor impact on water quality. The contractor will be allowed additional time to drive the piles between April and July while all other operations possibly affecting water quality will be restricted to the July to September 15 period.

The Department of Fish and Game also stated that material from the roadway construction should not be allowed to enter the live streams. Provisions in the construction specifications will require the contractor to prevent stream pollution during construction. The contractor will also be required to provide temporary erosion-control measures which may become necessary as a result of construction operations. All Department of Fish and Game regulations and recommendations will be complied with. Section III-D-1 will discuss in more detail the proposed mitigation measures on water quality.

Mr. John Brode of the Department of Fish and Game was consulted in October of 1972 about the giant garter snake. He said the Mokelumne River overflow area did provide the type of habitat frequented by the giant garter snake. He also stated that to his knowledge there had been no sightings in the area. In the spring of 1973 he investigated the area and reported that the project did not traverse a substantial portion of the snakes normal habitat.

This project lies within the Pacific flyway of migratory fowl in Northern California. Its effect on migratory bird life is expected to be negligible as only a small percentage of potential resting and nesting areas within the Mokelumne River overflow area will be affected."

In regard to vegetation, the FEIS contained the following statement:

> "There is an abundance of riparian vegetation along the natural use waterways of the Mokelumne River area and efforts will be taken to preserve and to protect the existing vegetation wherever possible. Caltrans' Standard Specifications (Section 7-1.01L) requires the construction contractor to exercise care in preserving roadside vegetation beyond the limits of construction. The contractor will also be required to confine his clearing of vegetation to the actual limits of earthwork (tops of cuts and toes of fills) in those area of significant vegetation. Additional protection will be provided by minimizing the area of bare soil and time exposed, maintaining drainage patterns, controlling runoff concentrations, and trapping sediments in silting basins."

Photos 78 to 85 provide a general panorama of the project.

From the background water-quality information, the District 03 Environmental Branch projected possible impacts from the proposed construction. The estimated impacts are described in the District 03 Water Quality Report as follows(37).

> "Sedimentation is the most serious potential impact on water quality that can occur from highway facilities, because its effects are so diverse, and it is generally the major vehicle that a highway facility has for the pollution of water. By far, the greatest source of this pollutant is during the construction period.
>
> On the proposed project, the most sensitive area for the sedimentation impact is where the proposed alignment of this freeway intersects the Mokelumne River and its overflows, Middle Slough, and Lost Slough.

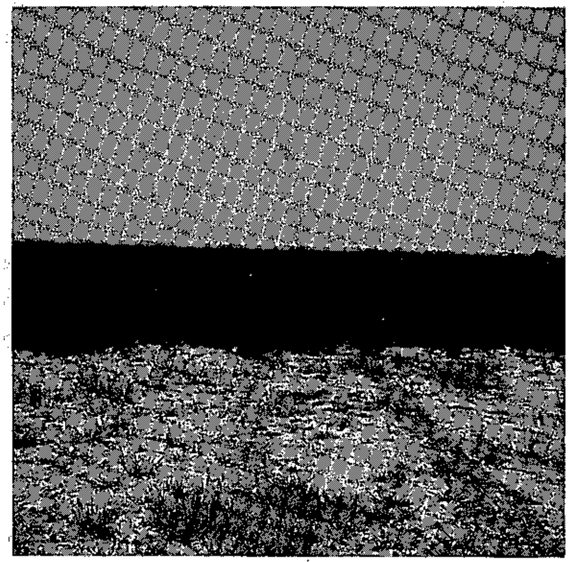


Photo 78

Looking South from Lambert Road at the Proposed I-5 Centerline. This is the North End of the Project.

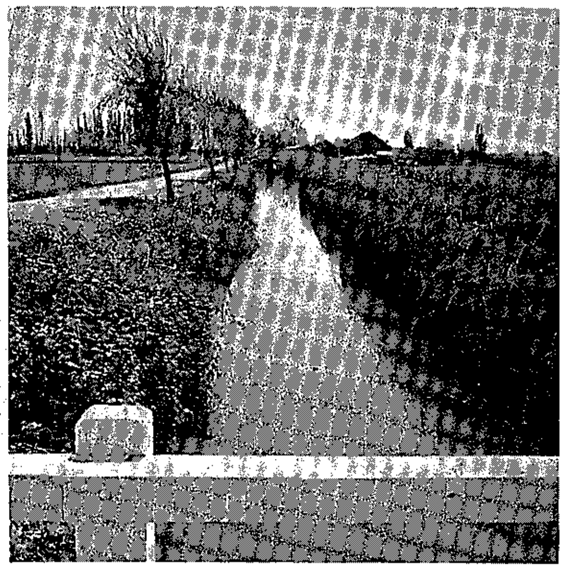


Photo 79

The Runoff Water from Irrigation as well as the Natural Drainage Water, Flows in a Southwesterly Direction in a Series of Return Ditches and is Pumped into Lost Slough. The Pumps are Located at the far end of this Ditch.

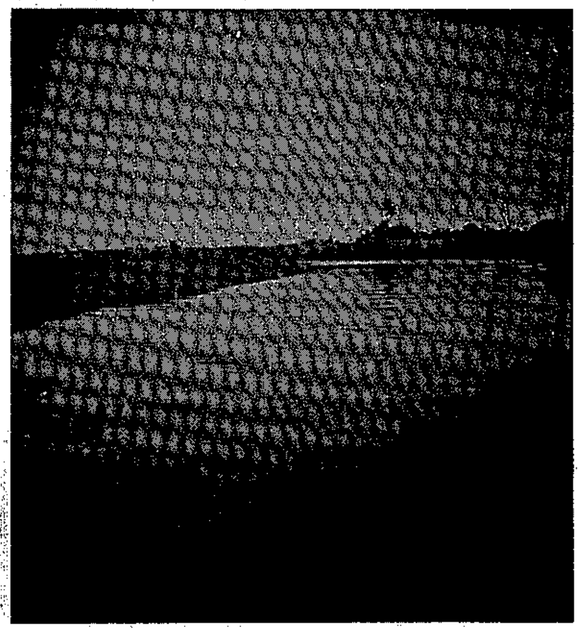


Photo 80

Upstream View of Lost Slough
from the Proposed Bridge Site

Photo 81

Proposed Site of the Lost Slough Bridge

Photo 82

Looking North at the Proposed I-5
Centerline from the Mokelumne River

Photo 83

Proposed Site of the Mokelumne River Bridge

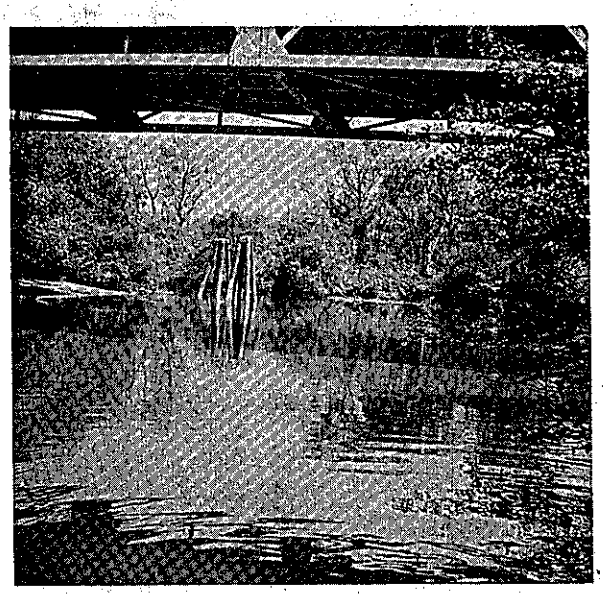


Photo 84

Mokelumne River at the Intersection of Franklin Boulevard, Approximately 2000 Feet Upstream from Proposed I-5

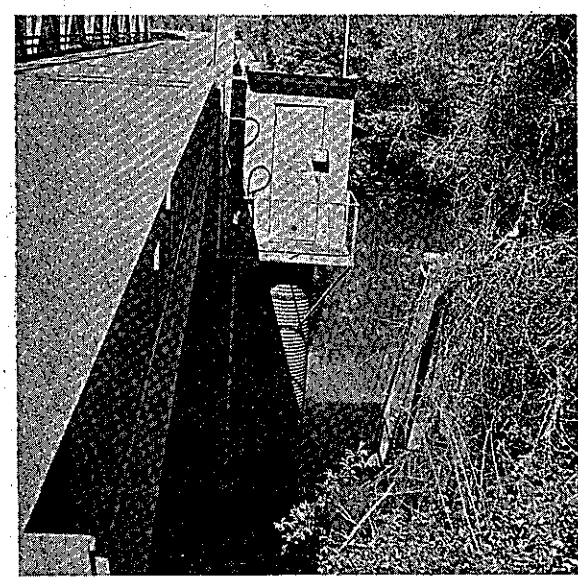


Photo 85

Department of Water Resources Recording Stage Gage at Mokelumne River and Franklin Boulevard

When the bridge pilings and their foundations are placed within these waterways a temporary impact from increased sediment disturbance and turbidity will exist. Degradation will also take place after the piling foundations are constructed until the river beds reach equilibrium again.

The entire project, as proposed, will be constructed upon embankment material with an average fill height of three to five feet. These fill heights will be raised to 17 or 18 feet for the structures at Mokelumne River, Middle Slough, and Lost Slough in order to insure adequate waterway clearance for pleasure boats under the structures. The placement of the bridge approach fills, as with the placement of any fill, has its greatest potential impact during the construction period. There is an increased danger from these bridge approach fills however, in that they will be placed in the Mokelumne River overflow area.

A temporary impact from increased sediment disturbance and turbidity can also be expected during the placement of the rock-slope protection around the south approach fill for the Mokelumne River Bridge if a foundation trench is required below the river bed to anchor the rock-slope protection.

Of the three waterways mentioned, Lost Slough will be the most sensitive to any potential impacts on the water quality from this proposed freeway. There are two reasons for this statement: (a) the removal of unsuitable material for approximately 300± feet beneath the proposed south approach fill, the placement of rock-slope protection around the north approach fill, and (b) the drainage pattern for the area north of the slough.

(a) There will be a temporary impact on the water quality in Lost Slough from increased sediment disturbance and turbidity during the removal of the unsuitable material and the replacement of this unsuitable material with an appropriate granular-backfill material. To a lesser degree, the same type of impact will occur during the placement of rock-slope protection around the north approach fill for the Lost Slough Bridge if a foundation trench is required below the slough bed to anchor the rock-slope protection.

(b) Approximately 75% of the proposed freeway lies north of Lost Slough, and the natural drainage flow is to the southwest. The runoff water from the freeway will be collected in a series of toe-of-fill ditches and discharged into Reclamation District 1002's drainage ditches. The water in these drainage return ditches flows south and is pumped over the levee into Lost Slough. In other words, 75% of the proposed freeway will be drained into Lost Slough, consequently, Lost Slough will be the largest recipient of any potential impact on water quality from the proposed project.

The Department of Transportation intends to sample the water in the main-drainage-return ditch just prior to its being pumped over the levee into Lost Slough before, during, and after construction in order to evaluate the ambient conditions and the control and mitigation measures."

The Water Quality Report recommended the following mitigation measures for the I-5 project(37):

"Erosion and Sedimentation

The major area of concern regarding water quality is the Mokelumne River and its overflow areas, Middle Slough and Lost Slough, during construction. Proper construction procedures will minimize any potential ampacts to the water quality of this area.

A system of cofferdams, constructed of sheet piles, and settling basins will be placed before the actual construction of the bridge pilings and their foundations is started. The excavated saturated material will then be taken from the cofferdams and placed in the settling basins to permit the sediment to settle out before the water is returned to the river, or it will be placed in an area where it can be contained and not returned to the river at all.

An increase in sediment disturbance and turbidity can also be expected during the removal of 300± lineal feet of unsuitable material from beneath the proposed south approach fill for the Lost Slough Bridge, and the replacement of this unsuitable material with an appropriate granular backfill material. There are several construction procedures being considered for this removal, but at the time of this writing, the selected technique and details are not available. Whichever construction method is employed, the predominant theme will be the protection of the waters in Lost Slough, and this construction method will be discussed with the regulatory agency, the State Water Resources Control Board, before the construction contract is advertised.

The same type of impact, as mentioned above, but to a lesser degree, will occur during the placement of rock-slope protection around the north approach fill for Lost Slough Bridge, and the south approach fill for the Mokelumne River Bridge if foundation trenches are required below the stream beds to anchor the rock-slope protection. When the construction method is selected and detailed with emphasis on water-quality control, it will also be discussed with the State Water Resources Control Board, before the construction contract is advertised.

During the construction of the cofferdams and other protective devices there will be a slight, temporary sediment disturbance and an increase in turbidity.

The same will hold true from the degradation phenomenon until the bed reaches equilibrium, but these impacts will be transitory, and localized in nature, because the volume of the river and sloughs will dilute and reduce these adverse effects.

The impacts, mentioned above, can be further reduced if, in accordance with the Department of Fish and Game recommendations, any construction work located within the water of the main channels is completed between the dates of July 1 and September 15, so as not to interfere with the migrations of the anadromous fish that use these waterways.

The placement of the approach fills for the bridges in the overflow area is also a sensitive point during construction, but these fills will be built during the summer when the flow of the Mokelumne River is at its lowest and contained within its natural bed. Since the approach fills are located within the overflow area they will be finished and slope protection, if required, in place before the higher flows of the Mokelumne River encroach upon them.

During the design phase of this proposed project, the items listed below will be given special consideration in an attempt to minimize the potential impact of highway construction on the water quality.

(a) Identify variations in the erosive characteristics of the soils in the area so that proper protective measures may be taken.

(b) Provide for the preservation of roadside vegetation beyond the limits of construction by special provisions.

(c) Designed slopes will be as flat as is reasonable with slope rounding or contouring to minimize erosion and to promote plant growth.

(d) Seeding and planting of cut and fill slopes will be provided. Consideration will be given to the advisability of specifying completion of planting on exposed slopes by a certain date to winterize the project, temporary planting with quick-growing cover, or tying planting time to completion of slopes.

(e) Whenever planting must be delayed, temporary erosion protection with mulches, fiber mats, netting, dust palliatives, crust-forming chemicals, plastic sheets will be provided where necessary.

(f) Overside drains, surface, subsurface, and cross-drains will be designed so that they will discharge in locations and in such a manner that surface and subsurface water quality will not be affected. The outlets may require aprons, bank protection, silting basins, or energy dissipators.

(g) Bank protection where the highway is adjacent to the river or streams will be provided if their velocities are erosive.

(h) Slope protection or channel lining will be included for channel changes where required.

(i) Where the State has made arrangements for materials, borrow, or disposal sites, grading plans would be provided and reseeding required where practicable. Special provisions would be inserted requiring the contractor to furnish plans for grading and reseeding of sites obtained by him.

(j) Establish right of way widths of adequate space for rounding at tops of cuts and bottoms of fills and for adequate slope-protection ditches. Construction permits will be given consideration for temporary work such as silting basins, stream diversions, or stream crossing protection.

(k) All ditches subject to erosion would be paved. Consideration would be given to the use of soil cement in wide drainage areas that cannot be planted.

(l) Temporary construction features for the control of erosion and water pollution that can be predicted will be made a part of the plans, specifications, and contract pay items. Such items as extra seeding of slopes, berms, dikes, ditches, pipes, dams, settling basins, stream diversion channels, slope drains, and crossings over live streams will be considered. Since all contingencies probably cannot be forseen, supplemental work funds will be set up for unforseen problems.

(m) Mandatory contract orders of work will be considered where their use would eliminate the expense of temporary construction or where they will result in earlier protection of erodible areas.

In addition to the design criteria listed above, the California Department of Transportation will require the contractor to conform to the following provisions:

(a) Where working areas encroach on live streams, barriers adequate to prevent the flow of muddy water into streams would be constructed and maintained between working areas and streams, and during construction of such barriers, muddying of streams would be held to a minimum.

(b) Removal of material from beneath a flowing stream would not be commenced until adequate means, such as a bypass channel, are provided to carry the stream free from mud or silt around the removal operations.

(c) Should the contractor's operations require transportation of materials across live streams, such operations would be conducted without muddying the stream. Mechanized equipment would not be operated in the stream channels of such live streams except as may be necessary to construct crossings or barriers and fills at channel changes.

(d) Wash water from aggregate washings or other operations containing mud or silt would be treated by filtrations, or retention in a settling pond, or ponds, adequate to prevent muddy water from entering live streams.

(e) Oily or greasy substances originating from the contractor's operations would not be allowed to enter or be placed where they will later enter a live stream.

(f) Fresh portland cement or fresh portland cement concrete would not be allowed to enter flowing water of streams.

(g) When operations are completed, the flow of streams would be returned as nearly as possible to the original meandering thread without creating a possible future bank erosion problem.

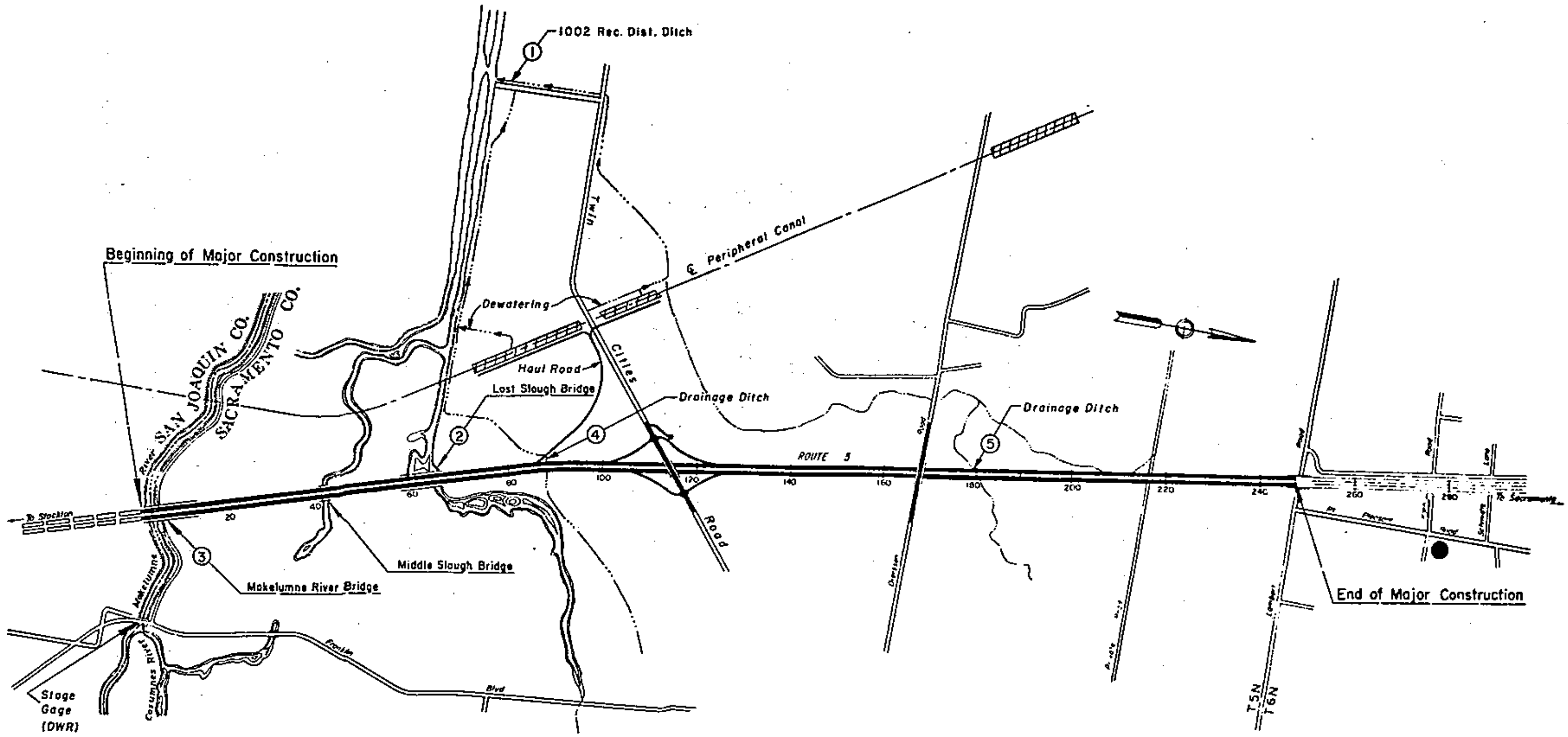
(h) Materials derived from roadway work would not be deposited in a live stream channel where they could be washed away by high stream flows.

(i) Sanitary facilities shall be provided at the job site which will not contaminate the ground or surface water as required by the Federal Occupational Safety and Health Act."

The District Construction Branch was apprised of these recommendations prior to the start of the construction project. The information was used by the Resident Engineer in evaluating the contractor's Water Pollution Control Plan submitted in fulfillment of Caltrans Standard Specification 7-1.01L before the start of construction(17).

Construction Monitoring (First Year)

Construction began on the I-5 project in south Sacramento County in 1977 and was scheduled to be completed in 1979. The TransLab Water Quality Section established 5 monitoring sites as shown in Figure 36 to record information only during the first year of construction. A precipitation gage was established at the Resident Engineer's office. Prior to construction, the contractor obtained the necessary permits from the Department of Fish and Game, and the Regional Water Quality Control Board.



LEGEND

② Sampling Locations

● Precipitation Gage

▨ Excavation Areas (Borrow Site)

CONSTRUCTION MONITORING SITES

TRANSPORTATION LABORATORY						
SAMPLING LOCATIONS						
DATE	DIST	COUNTY	ROUTE	POST MILE	DWG. NO	TOTAL SHEETS
	03	SAC	I-5	0.0/4.6	657081	

Figure 36

Although construction was to extend from 1977 through 1979, monitoring by TransLab was planned only for the fall and winter of 1977-78 because the research field study was scheduled for completion on June 30, 1978. It was felt that monitoring the initial stages of construction would provide some useful information on short-term impacts and their mitigation.

A schedule of testing is shown in Table 37. The sampling was accomplished by TransLab and District 03 Environmental personnel.

Sampling locations 4 and 5 are drainage ditches that deliver irrigation and drainage water to sampling location 1, the ditch with pumps to convey the water into Lost Slough. Photos 86 and 87 show the constructed cross culverts at these locations. Photos 88 and 89 show the location of the main return ditch and pumps.

Embankment material for the I-5 project was obtained from three borrow sites along the centerline of the proposed Peripheral Canal (see Photos 90 and 91). The borrow sites were dewatered during excavation. The water was pumped to Lost Slough where it was discharged. Discharge was allowed as long as the river water level was at, or below, 7 feet above MSL. The specific conductivity of the river water was used to determine if there were any adverse effects from the discharge.

To control erosion and subsequent impacts to the water quality from sediment, the contract special provisions included an item for erosion control (type C) as follows:

TABLE 37

SAMPLING AND TESTING SCHEDULE (OCTOBER 1977-APRIL 1978)

(03-Sac-I-5 PM 0.0/4.6)

Item	Location*	Frequency
Turbidity	2, 3	During Construction in Water
	4, 5	During Storms
Settleable Matter	2, 3	During Construction in Water
pH	1	Quarterly
	2, 3	During Construction in Water
	4, 5	During Storms
Dissolved Oxygen	1	Quarterly
	2	During Construction in Water
Temperature	1	Quarterly
	2, 3	During Construction in Water
Specific Conductance	Peripheral Canal	During Dewatering Operations
	1	Quarterly
	2, 3	During Construction in Water
Nutrients	1	Quarterly
	2, 3	During Construction in Water

*Sampling and testing at Location 3 (Mokelumne River) were scheduled, but construction in the river took place after the monitoring period.

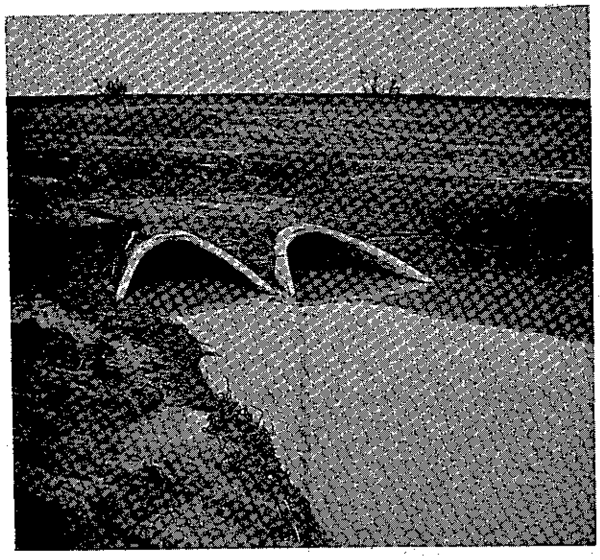


Photo 86

Cross Culverts at Sampling Location 4
February 1978

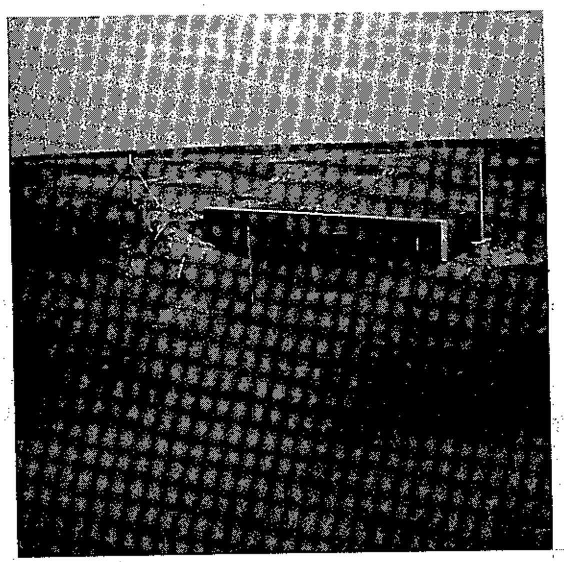


Photo 87

Cross Culvert at Sampling Location 5
March 1979

Photo 88

Runoff from Irrigation, as well as the Natural Drainage, is Collected in this Ditch & is Pumped into Lost Slough. Pumps are Located at the Far End of this Ditch.

Photo 89

Pumps for Conveying Water into Lost Slough

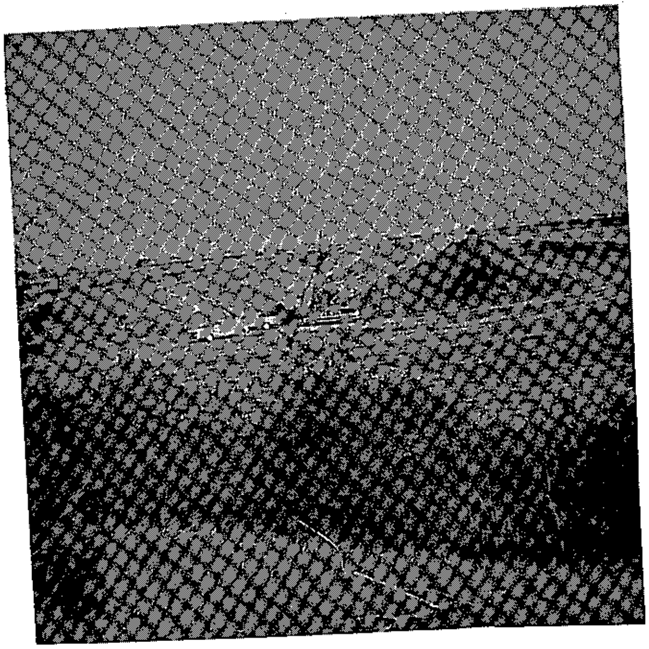


Photo 90

Excavation of Material from Peripheral Canal in September 1977 (Looking North from Lost Slough Levee)

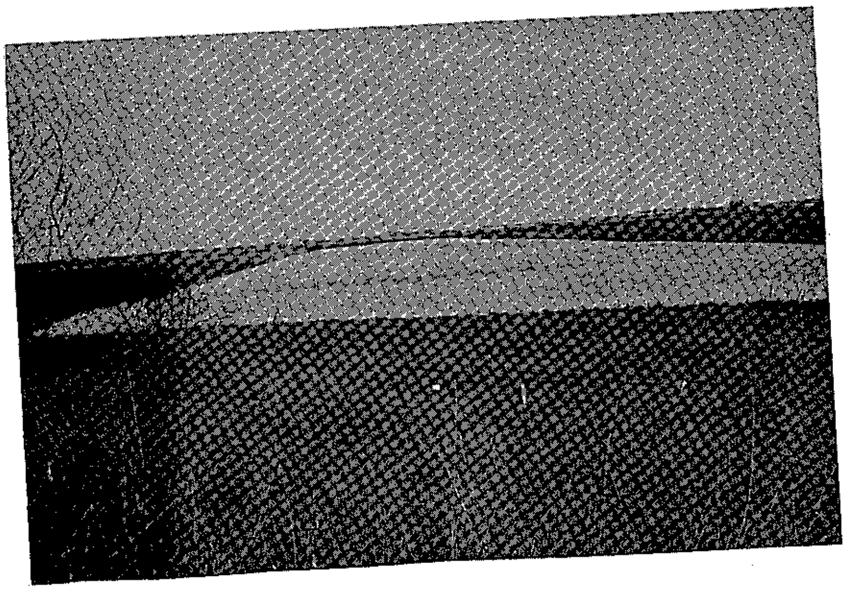


Photo 91

Same View of Peripheral Canal as Photo 90 in March 1979

"10-1.15 EROSION CONTROL (TYPE C).--Type C erosion control shall conform to the provisions in Section 20, "Erosion Control and Highway Planting," of the Standard Specifications and these special provisions.

The work shall consist of applying straw, seed and fertilizer to embankment slopes and excavation slopes 4:1 or steeper and seed and fertilizer to slopes flatter than 4:1 including median areas as shown on the plans.

When weather conditions are suitable, straw may be pneumatically applied by means of equipment which will not render the straw unsuitable for incorporation into the soil.

If the Contractor elects to apply seed and fertilizer with hydro-seeding equipment, the seed shall be applied together with a minimum of 500 pounds of fiber per acre. When the Contractor elects to apply the seed and fertilizer with hydro-seeding equipment, the fiber required for Type C erosion control will not be measured or paid for. Fiber shall be produced from non-recycled wood such as wood chips or similar wood materials and shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. Fiber shall not be produced from sawdust or from paper, cardboard or other recycled materials. Fiber shall be green colored to contrast with the area on which the fiber is to be applied, shall be nontoxic to plant or animal life, and shall not stain concrete or painted surfaces.

Mixing of materials for application with hydro-seeding equipment shall be performed in a tank with a built-in continuous agitation system of sufficient operating capacity to produce a homogeneous slurry and a discharge system which will apply the slurry to the slopes at a continuous and uniform rate. The tank shall have a minimum capacity of 1,000 gallons. The Engineer may authorize use of equipment of smaller capacity if it is demonstrated such equipment is capable of performing all operations satisfactorily.

A dispersing agent may be added to the slurry provided the Contractor furnishes evidence that the additive is not harmful to the mixture. Any material considered harmful, as determined by the Engineer, shall not be used.

The slurry shall be applied within 40 minutes after the seed has been added to the slurry.

Straw shall be applied evenly over the area to be stabilized at the total rate of approximately 4 tons per acre (slope measurement).

Prior to incorporation of straw into the soil, seed at the rate of 40 pounds per acre (slope measurement) and fertilizer at the rate of 300 pounds per acre (slope measurement) shall be applied.

Seed shall consist of the following:

Botanical Name (Common Name)	Percentage (Minimum) Purity	Percentage (Minimum) Germination	Pounds per acre
Agropyron trichophorum 'Luna' (Luna pubescent wheatgrass)	95	80	10
Dactylis glomerata 'Palestine' (Palestine orchardgrass)	85	80	15
Bromus mollis 'Blando' (Blando brome)	95	85	12
Lupinus nanus 'Sky' (Sky Blue lupin)	95	80	2
Eschscholtzia californica (California Poppy)	90	70	1

Prior to seeding, the Contractor shall furnish written evidence (seed label or letter) to the Engineer that seed not required to be labeled under the California Food and Agricultural Code conforms to the purity and germination requirements in these special provisions.

All legumes shall be inoculated with a viable bacteria compatible for use with that species of seed. The application rate for seed shall be the weight exclusive of inoculant materials. All inoculated seed shall be labeled to show the weight of seed, the date of inoculation, and the weight and source of inoculant materials.

Inoculated seed shall be sown within 20 days of inoculation or shall be reinoculated.

The legume seed shall be inoculated as provided in Bulletin AXT-280, "Pellet Inoculation of Legume Seed," of the University of California, Agricultural Extension Service, except the inoculant shall be added at the rate of 5 times the amount recommended on the inoculant package.

Seed shall be mixed on the project site in the presence of the Engineer.

Commercial fertilizer shall have the following guaranteed chemical analysis:

Ingredient	Percentage (min.)
Nitrogen	16
Phosphoric Acid	20
Water Soluble Potash	0

The contract prices paid per ton for straw, per pound for seed, and per ton for commercial fertilizer, shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in erosion control (Type C), as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer."

The erosion-control-permanent measures will be placed as the final road slopes are completed.

Summary

During fall 1977, the contractor concentrated his efforts in constructing the fill from Twin Cities Road south. This allowed the contractor to complete as much work as possible in the flood plain during the dry period. This required construction of temporary earth fills across Lost and Middle Sloughs. Although construction was to extend from 1977 through 1979, only the first year of construction was monitored.

Water samples were taken during the construction of the fill across Lost Slough. Settleable matter and turbidity analyses indicated temporary localized (within 200 feet downstream of fill) increases in these parameters. This temporary impact was described in the EIS.

Samples were taken at Locations 4 and 5 during several storms. Turbidity at Location 4 was much higher than at Location 5. Location 4 was in the vicinity of the constructed fill whereas the area near Location 5 was not yet under construction. The flow at both locations was low during sampling.

Photos 92 to 97 show the constructed bridge crossings at the Mokelumne River, Lost Slough and Middle Slough and fill in the area between Lost and Middle Sloughs.

Based on the short-term monitoring conducted during the first year of construction, no adverse effects were recorded. The EIS appears to have adequately addressed the project's impacts and mitigation. The project design and contract specifications adequately provided for protection of the water quality.

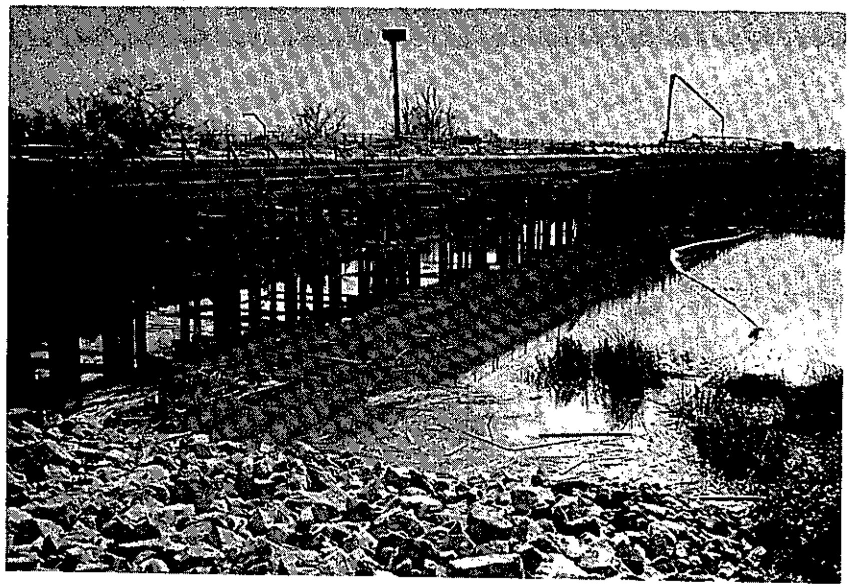


Photo 92

Lost Slough-Southbound Bridge
March 2, 1979

Photo 93

The Fill Between Middle Slough and Lost Slough (Looking South from Lost Slough) Overflowing at Middle Slough, Water Flowing Along the Toe of Fill & into Lost Slough (March 2, 1979)

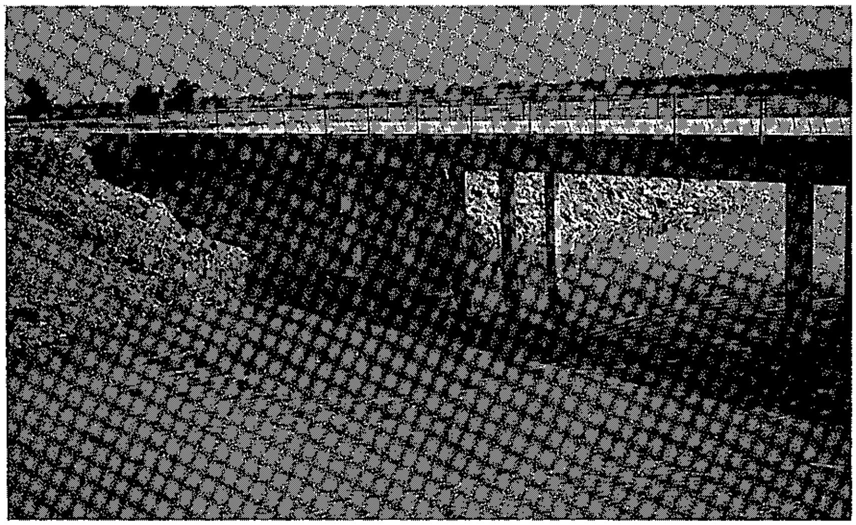


Photo 94
Middle Slough-Northbound Bridge
March 2, 1979

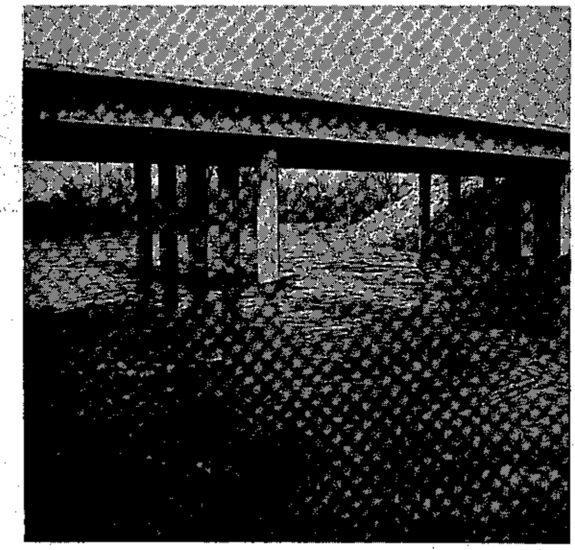


Photo 95
Middle Slough-Southbound Bridge
March 2, 1979

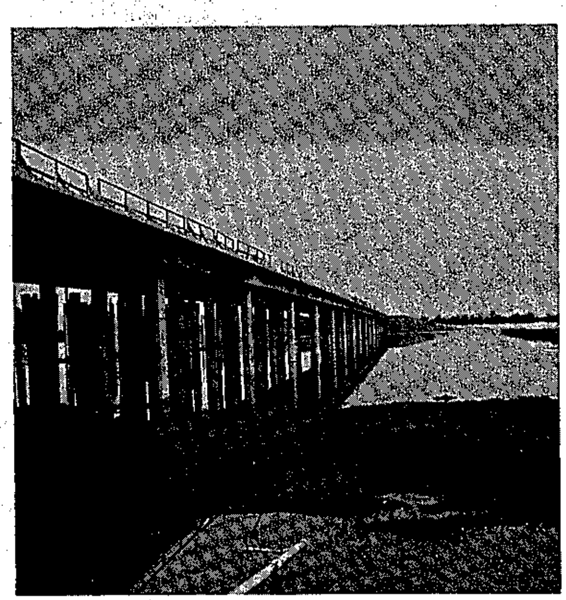


Photo 96

Mokelumne River Bridge Approach. Northbound
Constructed in the Mokelumne River Overflow
Area (March 2, 1979)

Photo 97

Mokelumne River Bridge-Northbound
Partially Built (March 2, 1979)

The Mokelumne River is one of the several important watercourses connecting with the San Joaquin Delta. It provides a fish run for salmon and steelhead. The watercourses in the project are influenced by tidal action. The preconstruction investigation of water quality by the district provided an abundance of background information on the delta and associated watercourses. Most of this information was gleaned from data collected through monitoring programs of the U.S. Bureau of Reclamation and the California Department of Water Resources. An examination of this information revealed that runoff from the proposed freeway would have no significant impact on the delta. Monitoring of the downstream, or delta, waters was not performed as part of this research. However, studies in the vicinity of the project site revealed no deterioration of water quality.

The dewatering operation during excavation of material from the proposed Peripheral Canal was not monitored by Caltrans. It was discovered that a similar operation on the San Joaquin County side of the I-5 project did result in increased conductivity downstream from the discharge. The increased conductivity exceeded the allowable limits of the discharge permit issued by the Central Valley Regional Water Quality Control Board. Modifications were made in the procedure, and operations were allowed to proceed. This indicates that in performing dewatering, removal of groundwater and subsequent discharge into surface waters may alter water quality. Groundwater should be tested prior to dewatering. If high levels of conductivity, turbidity, or other chemical parameters are anticipated, appropriate treatment systems should be designed that will insure compliance with discharge requirements. Monitoring during the operation should be maintained.

Because of the agricultural use in the project area, it was suspected that nutrients, pesticides, and coliform (from cattle grazing) would be high compared to non-agricultural areas. No tests were performed for these parameters because of the short duration of the study. For long-term studies, these parameters should be investigated.

Construction of the bridge piers in the Mokelumne River had the potential for impacting the river substrate in the immediate project vicinity. However, no adverse impacts were noted. Generally, if any impact had occurred, it would be short-term.

To reach a final conclusion as to the adequacy of the preconstruction district water quality study and Environmental Impact Statement, monitoring through construction scheduled for completion in 1979 and monitoring for a period following construction (approxmately one year) would be required. Without this information, no conclusions can be reached as to the overall project's impact.

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